

Neurological Examination In Infancy And Childhood

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The neurological evaluation of infants and children differs from that of older children and adults principally because of the phenomenon of development. The process of development alters the neurological behaviors and functions that would be expected at different ages. Development also changes the findings on physical examination. Finally, the natural history and manifestation of abnormal function and disease are very often different at different stages of development. Thus, development is an important variable in the evaluation of infants and young children.

Another important difference in this age group is that the medical history is usually provided by parents or other caregivers. These individuals can also be very helpful in assisting with the physical examination. Older children and adolescents, even if accompanied by parents, should be asked to describe the chief complaint and symptoms (which may be different from that given by the parents). They should also be given the opportunity and courtesy of meeting with the physician in private to discuss more personal concerns.

The goal of the neurological assessment is to detect abnormalities, to localize them and to monitor their changes. After a complete and successful neurological evaluation it will be possible to establish a diagnosis and recommend treatment, if indicated, or determine what further diagnostic testing is indicated.

The primary emphasis in this chapter is on the neurological examination but some suggestions regarding the neurological history are discussed. The examination described is more detailed than would be routinely performed, but in an individual patient such detail may be required in the area of suspected or actual abnormality. A different approach to the examination of specific age groups is recommended, and this is described at the end of the chapter.

HISTORY

The history is considered to be the most essential part of the evaluation. Usually, the attentive clinician will have formulated an appropriate differential diagnosis, if not the actual diagnosis, after completing the history. Thus, it seems reasonable to allot ample time to this part of the evaluation if the diagnosis has not already been established. Most clinicians also take advantage of the interview time to observe the patient's interaction with the parent or caregiver, the environment, and the examiner and to note the patient's spontaneous activity and function. The interview can provide an opportunity for the patient to become more comfortable with the examiner and to even begin to interact socially. This time can and does provide much of the information necessary to judge whether the patient's mental, visual and motor functions are grossly normal.

PRESENT ILLNESS

It is most important to have a complete description of the chief complaint. This should include the onset (acute or insidious) and the duration of the problem. It is important to determine whether the course has been acute, chronic or intermittent and whether it is static or progressive. Based on the complaints and relevant solicited information, one can usually determine which system is likely to be involved. It may be possible to implicate the cognitive and behavioral system, the cranial nerve and special sensory system, the pain and sensory system, the neuromuscular system or the motor control system or to determine whether there are multiple areas affected or there is more general or diffuse involvement. Identifying the pattern of involvement can help to narrow the diagnostic possibilities.

It is very useful to summarize and reiterate for the parents their concerns and complaints and what one perceives to be the most important of the problems. Not only does this serve to reassure the parents that the clinician has heard and understood their history, but it also allows the clinician to determine if there are any other areas not mentioned that are of concern to them.

BIRTH HISTORY

For the neonate or the older infant and child whose symptoms date to early infancy, a detailed birth history is essential. It is being increasingly recognized that many of the neurological disorders present at birth had their onset, from either damage or developmental abnormality, during gestation. A complete pregnancy history should include gestation time, maternal illness and exposure to both legal and illicit drugs including alcohol and any previous history of spontaneous abortions. The history taker notes the occurrence during the pregnancy of infections, vaginal bleeding, symptoms of toxemia and polyhydramnios or oligohydramnios. The history should determine whether there was prenatal care, whether the infant was monitored, whether fetal ultrasound and other diagnostic tests were performed and whether there was any evidence of fetal distress. Increasingly a number of congenital malformations involving the nervous system are being identified with prenatal ultrasound imaging.

It is important to know the type and duration of delivery, whether it was difficult, whether the presentation was unusual, whether there was evidence of abruptio placentae or mal-positioned placenta and whether there was premature rupture of membranes. It should be noted whether there was a prolapsed cord at birth and what the condition of the newborn was (e.g., Apgar scores, cyanosis, breathing, requirement for resuscitation). Did the infant feed well after birth, develop an infection or become jaundiced? Finally, one should record the infant's birth weight, head circumference and whether there were any obvious birth defects. Respiratory distress, apneic episodes, seizures, bleeding and duration of stay in the nursery may all be helpful clues to an abnormal neurological state of the newborn.

DEVELOPMENTAL HISTORY

The developmental milestones are an extremely important measure of the preschool child's neurological development. In the older child, school performance also becomes an important indicator of development. It is convenient to consider the developmental milestones in four categories, namely, motor behavior, adaptive behavior, language behavior and personal-social behavior. Normal motor development is reassuring regarding any underlying motor abnormality. Normal language development (see table 1) and adaptive behavior (see table 2) are strong predictors of normal cognitive outcome. Normal personal-social behavior is less significant in terms of prediction than is the presence of abnormal development in this area. With the possible exception of motor development, most of these factors can be heavily influenced by the patient's cultural, social and educational environment. Because school is such an intense and demanding experience, existing cognitive deficits are magnified and minor unrecognized problems (e.g., learning disability) are initially manifested at this time. Good school achievement and function is a reassuring sign of normal cognitive development. On the other hand, deterioration in school performance can be a very sensitive and early sign of a newly acquired or progressive neurological abnormality.

PAST HISTORY

The family history is of great importance for several neurological disorders. The ages and health of siblings and parents are noted and the cause of death of any immediate relative should be ascertained. The parents should be questioned about consanguinity and the presence of any neurological or familial disease in the family. The social status of the family and child should be noted, including the living conditions, the integrity of the family, who the usual caregivers are and the presence of drug usage in the patient or other family members.

In the review of past health, the history of injuries, hospitalizations, operations, illnesses, medications, immunizations and allergies may be important for understanding the patient's current problems. In addition a review of systems should include both general and systemic organ dysfunction as well as neurological dysfunction. Some relevant neurological symptoms are seizures, headaches, weakness, development delay, regression, visual disturbance, hearing loss, enuresis and incontinence.

PHYSICAL EXAMINATION

Because the nervous system interacts with so many other organ systems in the body it is important to know if other areas are dysfunctional. The physical examination is usually performed at the same time as the neurological examination. Similarly the examination is adjusted to the age of the child. Very often it is most effective if the patient is initially examined in the parent's lap. At some time during the examination the patient should be disrobed to their shorts in males, and shorts and top in females in order to detect skin marks or other abnormalities which would be concealed by the clothing. Older female patients must always be examined in the presence of a parent or female aide.

The minimal equipment for a routine examination for patients of all ages includes a tape measure, a stethoscope, a light, an ophthalmoscope, an otoscope, a tuning fork, a reflex hammer, wooden tongue depressors, cotton or tissue wipes, a bright squeaky toy, paper

and pencil or crayon, and items such as coins, paper clips, round balls, safety pins and keys.

In addition to the routine examination the following physical characteristics are of particular interest in the neurological assessment:

Measurements - height, weight, length and vital signs.

Skin - birthmarks, rashes, sinus tracts and unusual tufts of hair.

Head/face - cranial sutures, fontanelles, shape, deformity or dysmorphic features and bruits (perform auscultation).

Neck/spine - scoliosis, kyphosis, palpable or visible spine defect and meningeal signs (e.g., the Kernig and Brudzinski signs).

Cardiovascular - cardiomegaly, heart murmurs and peripheral pulses.

Abdomen - hepatomegaly, splenomegaly and distended bladder.

Musculoskeletal - atrophy, hemihypertrophy, contractures, muscle tenderness, pes cavus, club foot and other deformities.

MENTAL STATUS EXAMINATION

Mental status can be evaluated in children of all ages. The usual adult approach may be taken with children over age six with consideration of the different capacities of patients in the younger age groups. The assessment of mental state must consider language and culture differences. Primary sensory deficits (e.g., deafness, blindness) or motor deficits (e.g., cerebral palsy) must be recognized, and their effects on the assessment of mental function should be considered. To accurately assess mental state the patient should be alert and awake. State is one of the components of consciousness. The second component, awareness, reflects cognitive functioning. It ranges from full orientation and cognitive function, to confusion, to total lack of awareness. Delirium describes an acute, active confusional state with disordered thinking, cognition and perception, often with agitation. Decreased levels of alertness or arousal are associated with depressed awareness, but abnormal awareness may be seen in an awake individual.

The approach to mental status evaluation should be adjusted to the age of the patient. Up to approximately age six months, mental status is assessed through review of the history and, to a lesser extent by observation, of the early developmental milestones (see tables 1 and 2). The clinician notes the patient's attentiveness and awareness of the environment as well as his or her responsiveness to social stimulation (e.g., smile). The early foundations of speech, with cooing of vowel sounds, begin at this age and will evolve into babbling at the next stage.

After six months mental status is evaluated by determining the level of development of language and adaptive behavior (see tables 1 and 2). These are determined by review of

the developmental history provided by the parents and by observation of the patient in spontaneous activity and in response to the parents or examiner.

Normal language development follows an age-determined sequence, and the developmental level that the patient has achieved can be noted by comparison to this scale (table 1). It is practical to ask the parents about the milestones, that most patients of the same chronological age will have reached, to determine whether there is any developmental lag for the particular patient. If the patient has not demonstrated language function at the expected age level, then the level of function that best describes their language development is determined. A 3-year-old who is just beginning to put words together in phrases or sentences would be considered to be functioning at an approximately 2-year-old level regarding language. Attempts should be made to confirm the parent's description by observing and speaking with the patient during the entire examination.

Another measure of cognitive development is adaptive behavior. This refers to the faculties that reflect a child's ability to initiate new experiences and to learn from them. This includes understanding, concept formation and imagery. As with language there is a series of developmental sequences, and patients can be assessed to determine what level in this sequence they best fit and how this level compares to normal expectations (see table 2). This measure has a fairly good correlation with overall intelligence. The patient's level is estimated by review of the history provided by the parent and by the observation of spontaneous or elicited behaviors and functions at the time of examination. There are several accessories that will be useful for the examination. This includes several one inch building blocks of different colors, toys of interest to a child including ones with which he or she can interact (e.g., doll, truck), a book with pictures and simple text and a container into which the child can put a pellet or other object.

After the age of 6 years the more standard mental status examination can be performed. Cognition can be considered to consist of those functions that are lateralized and those that have more general or bilateral distribution. Language is lateralized to the dominant hemisphere, which is generally the left hemisphere. Visuospatial analysis is thought to have greater representation in the non-dominant hemisphere.

It is important initially to determine the general level of orientation of the older child. This will be an indication of the level of cognitive ability and of awareness. Patients should be asked questions that measure their orientation to time, including the day, date, month, season and year. Do they know where they are located in terms of building, room, city, region and country? They should be asked whether they recognize the other people in attendance, including the examiner, and this questioning should include individuals whom they would be expected to recognize. Right-left orientation should be included. Handedness of the patient may be determined at this stage and should be recorded. Most children demonstrate a hand preference by four years of age. If a child less than one year of age shows strong hand preference, it usually indicates motor abnormality involving the other hand.

Memory consists of short-term memory and long-term memory. The former includes working memory, the function of which is to hold information while it is being processed. This type of memory can be tested by digit span, immediately repeating three items or spelling a word backwards. At 4 to 5 years the child should be able to remember four digits and at 10 years six digits. The normal adult can remember seven or eight digits.

Long-term memory can be considered to be explicit or implicit. Explicit refers to memory of specific events or episodes (episodic memory) or facts, concepts, words and meanings (semantic memory). This type of memory has bilateral representation involving diencephalic, hippocampal and limbic structures. Semantic memory also involves the temporal neocortex, particularly in the dominant hemisphere. Explicit memory relates to knowing "that", whereas implicit or procedural memory relates to knowing "how". Implicit memory refers to the kinds of memory traces that are required when learning skills of procedures such as riding a bicycle or playing a musical instrument. This type of memory seems to involve mainly the basal ganglia, certain parts of the cerebral cortex and probably the cerebellum.

The clinician tests memory at the bedside by asking the patient to recall three or more items, a name and an address, a short story or a complex figure that has been presented over 5 minutes previously. Particularly in cases of head injury it may be useful to assess retrograde memory. This is generally not possible in younger children.

Language includes speech, reading and writing. Loss of language results in aphasia or dysphasia, which can be described as global, expressive or receptive. Wernicke's area in the posterior superior temporal lobe is important for language comprehension and reception. Broca's area in the inferior frontal lobe is involved in speech production and fluency. The connection between these areas, the arcuate fasciculus, couples comprehension and reception to expression. Damage here produces a disorder (conduction aphasia) in which repetition is disturbed and speech, while fluent, has paraphasic errors such as substitution of letters, syllables and words. Articulation, fluency, prosody (intonation and stress), vocabulary and word substitution errors should be noted during spontaneous speech. Further testing should include naming of objects, pictures or colors. Comprehension should be tested first with the use of three part commands such as "close your eyes, turn your head to the left and touch your left hand to your right ear" or simpler commands if this is not possible. The clinician can test for repetition by using single words and then progressing to a longer test phrase such as the popular "no ifs ands or buts".

Reading aloud is a good screening test because it requires several neurological abilities in addition to reading. Writing also tests several neurological functions particularly if it is a spontaneous composition by the patient about a person, place or event. If this spontaneous composition is not possible then writing to dictation will give some indication of the patient's ability in this area. Spelling is also a useful bedside test of language function and level of cognitive ability.

Calculation is considered to be another dominant hemisphere function residing in the angular gyrus region. A simple screening test would be to ask the patient to subtract simple numbers such as 21 minus 17 or 31 minus 9. More difficult calculations may require paper and pencil.

The most easily demonstrated abnormality of the non-dominant (usually right) hemisphere is the phenomenon of neglect. This abnormality is detected by having the patient draw from memory a picture of a clock face or of a daisy flower. In obvious neglect there will be much poorer construction of the picture on the left side. If there is a visual field deficit, however, this can not be considered to be evidence of neglect. Visuospatial function may also have a non-dominant hemisphere localization. In any event it is a useful mental function to be examined. Copying complex designs and drawing a person are useful bedside tests for which developmental standards are available (e.g., Greek cross, age 8 years; cylinder, age 9 years; and a three-dimensional cube, age 12 years).

CRANIAL NERVE EXAMINATION

Cranial Nerve I (Olfactory nerve)

Although children and infants, including neonates, can detect olfactory stimuli, an olfactory test is often not included in the routine cranial nerve examination. For more formal testing, a supply of materials that have distinct but not strongly aromatic odors, such as coffee, orange, vanilla, and mint, may be used to test each nostril separately. With one nostril occluded the patient is asked to sniff to detect an odor. During one of the sniffs the test substance is brought close to the nostril. The ability to first detect and then identify the test substance and the number of sniffs needed to do that reflect different levels of sensitivity. Testing of neonates and infants requires more specialized testing procedures.

Cranial Nerve II (Optic nerve)

In premature and full-term neonates, infants, or the less cooperative patient, the blink response and the pupillary responses to light should be detectable. There should be a direct and a consensual pupillary response. The clinician should evaluate for the presence of a relative afferent pupillary defect (Marcus Gunn pupil) by swinging a light from one pupil to the other and back. The pupil with the relative afferent pupillary defect will dilate when the light is immediately directed to it from the other pupil. Even the neonate should show visual fixation and visual following if vision is intact and the patient is alert and not crying. Lack of fixation and following is non-localizing and can be due to lack of attention, cognitive impairment, decreased level of consciousness or visual pathway dysfunction anywhere from the eye to the occipital cortex. The size of the pupil and the possibility of pupillary anisocoria should be noted.

Visual acuity can be formally tested in cooperative children older than 4 years of age with the use of a visual chart both for near and far vision. A note should be made as to

whether the patient wears glasses and whether these were used for the testing. If the patient does not know the alphabet, the clinician can use a chart with toy diagrams that the child can name or the letter E chart and have the child indicate the direction in which the arms of each E are pointing. Each eye should be tested separately. A simple bedside test of acuity is to use a very small piece of tissue into a ball approximately 1 mm in size. The patient is asked to pick up the small object. If the patient can do this with the object at least 18 in. away, then the near vision in at least one eye is at the level of 20/40 to 20/60. If the patient cannot see that object, then larger items can be used. At birth the vision is about 20/150 and it matures to 20/20 after 12 months of age. Infants can follow a face or bright object, such as a multicolored ball or toy. The clinician can test for color vision informally by asking the child to pick up a specific color from a collection of different-colored items (e.g., crayons) or more formally by using an Ishihara color chart.

The visual fields are tested by confrontation of each eye separately. The cooperative patient is instructed to look at the examiner's eyes or nose and to report when a moving object comes into view. Moving fingers are brought in from each visual quadrant randomly until each quadrant and each eye are tested. A more sensitive method for picking up relative field defects is double simultaneous visual stimulation. The clinician simultaneously presents two targets to different quadrants and the patient is asked to point to the hand or hands with moving fingers. Older patients can be asked to count the number of fingers that are presented simultaneously in the different quadrants. In less cooperative patients the clinician may grossly assess visual fields by using visual threat, in which the hand is rapidly moved toward the eye from different directions, and noting a blink response. To test infants, the clinician brings an interesting object from behind the infant's head into a visual quadrant and notes the patient's response as the target comes into view. The lack of visual response in the presence of a normal pupillary response to light suggests a cortical deficit or cortical blindness.

Funduscopy examination may be facilitated by instillation of a drop of 2.5% phenylephrine hydrochloride and 0.5 or 1.0% tropicamide or similar ophthalmic preparation on the cornea to dilate the pupils. Very often for routine testing, the disc and adjacent retina can be seen without pupillary dilation, particularly if the examination is done in a somewhat darkened room. Newborns are often more easily examined than are somewhat older infants, who are more likely to resist examination. An assistant or a parent standing behind the examiner should try to attract the attention of the patient away from looking at the ophthalmoscope so that the examiner can get a good view of the optic disc. If the patient does look at the ophthalmoscope, this may be an opportunity to view the macula. In addition, the vessels and the peripheral retina should be examined for lesions such as chorioretinitis and retinitis pigmentosa. The margins, color and shape of the optic disc should be noted. In early papilledema there is blurring of the margins, venous distention and hyperemia of the optic nerve head. In more advanced papilledema, there is elevation of the disc, obliteration of the optic cup, hemorrhage and exudates. Optic nerve pallor indicates optic atrophy which may be difficult to recognize in the normally pale optic disc of the young infant.

The clinician begins the examination of the fundus with a high plus lens at a distance

from the eye looking for a red reflex and for abnormalities such as cataract. The examiner moves closer to the eye, decreasing the plus power toward the minus side until the fundus structures come into view. In the newborn and the younger infant, a high minus reading such as 8 or 15 often gives the best visualization.

Cranial Nerves III, IV & VI (oculomotor, trochlear and abducens nerves)

Cranial nerves III, IV, and VI subserve eye movement, and the third nerve also mediates pupillary constriction and lid elevation. The clinician should observe spontaneous movements of the eyes looking for conjugate movements, abnormal movements or limitations in movement. In newborns and in unresponsive patients, the oculocephalic reflex (doll's eyes maneuver) produces lateral eye movements that should be conjugate and full. In this test, if the head is rapidly rotated to one side the eyes temporarily deviate to the opposite side. Infants will follow a bright object or toy. Older children can cooperate with formal testing of eye movement. Such testing should be done with both eyes moving in the vertical and the horizontal meridians and in intermediate directions in each quadrant. If there is a question of abnormality, then each individual eye must be tested separately. The child should be asked if there is any evidence of diplopia and, if so, in which direction of gaze the diplopia is most severe. The child should also be questioned about the position of the two objects relative to each other.

In the infant there may be strabismus with esotropia, exotropia, hypotropia or hypertropia. This deviation may be obvious or may be detected by the reflection of the light on the pupil. If the eyes are aligned the light reflection should be in the same part of the pupil of both eyes. The clinician may detect subtle weakness or evidence of a tendency for strabismus by performing the cover-uncover test. In this test, the vision of one eye is blocked from the target by the examiner's hand and then the hand is moved to the other eye thereby blocking it from the target. The examiner watches the movement of the eye that is uncovered as the hand moves to cover the second eye. An inward movement, for example, indicates exophoria or weakness of the medial rectus muscle in that eye. In cases of diplopia it is useful first to determine in which direction the double vision is greatest because this indicates that one of the muscles most responsible for movement in that direction is involved. The most distal image belongs to the eye that has the abnormal function. The clinician can determine which eye is abnormal by covering one of the eyes with a red filter and determining whether the most lateral spot of light from a penlight is perceived by the child as red or white.

The third cranial nerve innervates the medial rectus, the superior and inferior rectus, the inferior oblique and the levator muscles of the upper eyelid and supplies the parasympathetic constrictor fibers to the pupil. The superior rectus muscle elevates the eye, the inferior rectus muscle depresses the eye and the medial rectus muscle adducts the eye. The inferior oblique elevates the eye and rotates it outward. Weakness of the levator palpebrae results in ptosis, or drooping of the eyelid. Involvement of the parasympathetic fibers results in pupil dilation. Lack of pupillary constriction to light reflects blindness, efferent third nerve abnormality or pupillary sphincter dysfunction. A small pupil may be associated with Horner's syndrome (miosis, ptosis, enophthalmos and ipsilateral facial anhidrosis) due to disruption of sympathetic innervation. A large pupil

may reflect pupillary constrictor dysfunction due to lesions of the Edinger-Westphal nucleus or third nerve. Pupillary constriction or dilatation can also be due to pharmacological effect.

The fourth cranial nerve innervates the superior oblique muscle which primarily rotates the eye inward (intorsion) and depresses the eye. Weakness of this muscle may result in a head tilt to the opposite side to compensate for the lack of intorsion. The sixth cranial nerve innervates the lateral rectus muscle, which abducts the eye. Internal ophthalmoplegia is paralysis of the pupillary sphincter and ciliary muscle (accommodation) only. Paralysis of the extraocular muscles only is termed external ophthalmoplegia. Paralysis of both is referred to as complete ophthalmoplegia.

In addition to abnormalities of the nerves or muscles they innervate, or both, there can be internuclear abnormalities. The medial longitudinal fasciculus serves to yoke the movement of the two eyes in a conjugate fashion. Unilateral medial longitudinal fasciculus lesions produce an internuclear ophthalmoplegia (INO) consisting of ipsilateral medial rectus involvement and contralateral lateral rectus involvement when the patient looks to the contralateral side. This condition is manifest as a lack of adduction of the ipsilateral eye and nystagmus in the abducting eye.

Supranuclear abnormalities produce gaze disturbances in which the conjugate movement of both eyes during gaze either vertically up or down or horizontally left or right is impaired. Vertical upward gaze is controlled at the pretectal dorsal midbrain level. Parinaud's syndrome constitutes impaired conjugate upward gaze with pupillary and convergence abnormalities. Lateral gaze is controlled by the pontine gaze center, which is responsible for gaze ipsilaterally. Higher cortical gaze centers control gaze contralaterally. Convergence is also mediated by internuclear mechanisms and is generally associated automatically with accommodation.

Eye movements can be described as "pursuit" when they smoothly and steadily follow an object or "saccadic" when they jump quickly from one target to another. The latter is more of a ballistic type of movement. Pursuit movements may not be smooth, but show a jerky irregularity as the movement is fragmented into individual and multiple saccadic jumps (saccadic pursuit).

Nystagmus is a repetitive to-and-fro movement of the eyes. When movements in one phase are saccadic and movements in the opposite direction are slow and smooth, it is called jerk nystagmus. If both phases are the smooth, the nystagmus is called pendular. In jerk nystagmus the direction is named according to the direction of the saccadic phase. Vestibular nystagmus is a jerk nystagmus. Disorders affecting the visual pathways, however, can produce pendular nystagmus. The roving eye movements of a blind infant are somewhat different but may be accompanied by pendular nystagmus. In congenital nystagmus both jerk and pendular nystagmus can be seen. Nystagmus can be further described by the eye position in which it is apparent. Thus, gaze evoked nystagmus may be present only when the patient is looking in one direction. Unilateral gaze evoked jerk nystagmus implies unilateral labyrinthine or vestibular abnormality. Vertical jerk

nystagmus indicates central, usually brainstem, dysfunction.

Opsoclonus, a rapid nystagmus-like oscillation of the eyes that occurs episodically is due to rapid volleys of saccadic conjugate-appearing movements in any direction. This gives the appearance of dancing eyes. It is seen in children in conjunction with the opsoclonus-myoclonus-ataxia syndrome, sometimes associated with neuroblastoma.

Cranial nerve V (trigeminal nerve)

There are both sensory and motor components to the fifth cranial nerve. Sensory testing in the neonate and infant relies on the infant's reflex or other response to stimulation. The corneal reflex can be elicited by touching the cornea with a wisp of cotton or a puff of air. There is a bilateral blink response. In the older infant, tickling the ear, nose and face with a piece of cotton or paper tissue will usually elicit the response of the infant bringing the hand to the site of stimulation. Sometimes a sneeze is elicited when the nose is stimulated. In the older child the clinician can make this sensory test more precise by having the child localize it with eyes closed localize it by touching the site of stimulation. This test requires detection of the stimulation as well as point localization. The clinician can test for pain with a clean, sharp disposable object (e.g., wooden applicator stick) by stimulating areas in each region of the trigeminal distribution, namely the ophthalmic, maxillary and mandibular divisions. Stimulating the forehead or just above the hairline (ophthalmic), the cheek (maxillary) and the chin (mandibular) elicits withdrawal and crying in newborns and young infants. This stimulation can be localized and the intensity reported by the cooperative older patient, who should be able to detect any differences between the left and right side of the face and between the face and other parts on the body. Sensation within the mouth has a cranial nerve distribution corresponding to that of the overlying external surface.

A sucking or biting response in neonates or young infants and their forceful opening of the mouth against resistance enable the motor function of the fifth nerve to be tested. Opening of the mouth, which is due to the action of the external pterygoid muscles, is more easily overcome in testing strength than is jaw closure, mediated by the masseter muscles. During the latter motion, however, masseter contraction and bulk can also be palpated.

Cranial nerve VII (facial nerve)

In newborns and young infants, the acts of smiling and crying provide a gross estimate of the function of the seventh cranial nerve, which innervates the facial musculature. Forceful eye closure either with crying or on request allows the strength of eye closure to be tested and compared on each side. In the patient at rest, a weakness of the orbicularis oculi may be manifested as a widened palpebral fissure on the affected side. Lower facial weakness manifests as a loss or decrease of the nasolabial fold on the affected side. The older child can make rapid lip movements, whistle and smile on request. Lower motor neuron seventh nerve weakness involves all muscles to a similar degree. Weakness due to an upper motor neuron lesion involving the seventh nerve generally spares the muscles in the upper part of the face, so wrinkling of the brow is unaffected. Some infants,

particularly those with congenital cardiac disease, have a developmental absence or hypoplasia of the depressor anguli oris on one side. This deficiency gives rise to an asymmetrical mouth during crying and apparent weakness of depression of the angle of the mouth. In facial weakness there can also be some alteration in articulation of speech.

Sensory and autonomic fibers originate with the facial nerve but branch off early. The lacrimal gland innervation passes through the nervus intermedius root of the facial nerve and branches off at the geniculate ganglion. Abnormalities of these parasympathetic fibers can produce a decrease in tearing. Fibers for taste sensation of the anterior two thirds of the tongue leave the facial nerve via the chorda tympani and join the lingual nerve. While taste is not tested routinely in infants, the clinician can test for it in older cooperative children by using solutions of sweet, salty, sour and bitter substances. One of these solutions is dabbed on the protruded tongue, and the patient should report the taste before the tongue is brought back into the mouth, where other receptors with cranial nerve IX innervation may detect it.

Cranial nerve VIII (auditory nerve)

The eighth cranial nerve has two components. The cochlear nerve deals with auditory function, and the vestibular nerve is related to labyrinthine function. Newborns respond to a loud whistle by alerting, opening the eyes, crying or otherwise changing their behavior. After several months of life, normal infants orient themselves to the sound and, after six months, can localize the sound. A squeaky toy, whistle, spoken word or tuning fork can be used to demonstrate this reaction. In the older child the detection of whisper or the sound of rubbing fingers can be used to estimate hearing acuity. A tuning fork of 256 Hz or higher is useful for hearing tests and for comparing hearing on the two sides. This instrument is also used for the Weber test, in which the stem of the tuning fork is placed at the vertex of the head and the patient is asked to localize the sound to one ear or the other or to the midline. Lateralization of the sound to the side of decreased hearing indicates that it is a conductive hearing loss, whereas lateralization to the side with normal hearing indicates that the contralateral hearing loss is of the sensorineural type. The Rinne test examines the relative efficiency of air conduction compared with that of bone conduction. The tuning fork stem is held against the mastoid bone for testing bone conduction, and the vibrating end is held near the external ear for the air conduction test. Normally, air conduction is more sensitive than bone conduction. A reverse of that relationship indicates conduction abnormalities in the middle ear. For more detailed testing of hearing, particularly in the newborn, the auditory brainstem evoked response is useful. Audiometry using behavioral responses in the younger infant and cooperative responses in the older child provides more detailed information on hearing acuity at different frequencies.

Vestibular function is not tested routinely but should be evaluated if abnormalities in vestibular function are suspected or patients have vertigo or nystagmus. The clinician examines for positional nystagmus and vertigo by quickly moving the patient's body and head into a recumbent position with the head turned with one ear down and then repeating the maneuver with the other ear down to see if any of these positions exacerbates the symptoms and the nystagmus. Caloric stimulation of the external

auditory canal is not generally done at the bedside in the awake patient but can be performed as a more detailed vestibular test in special laboratories. Ice water caloric testing of the unconscious patient with intact tympanic membranes is useful to assess the brain stem pathways from the labyrinth to the cranial nerves that control eye movement. Cold stimulation causes a deviation of the eyes to the stimulated side when the patient is in a recumbent position with the head tilted 30 degrees above horizontal. Newborns and young infants can be held by and facing the examiner, and when the examiner rotates with the infant, he or she will show eye deviation toward the direction of rotation. This response is mediated by the vestibular system. Oculocephalic reflexes (see above) also require vestibular activation.

Cranial nerve IX (glossopharyngeal nerve) and cranial nerve X (vagus nerve)

These nerves are usually tested together. Cranial nerve IX appears to provide much of the pharyngeal somatosensory and taste sensation innervation, while cranial nerve X integrates and controls the pharyngeal constrictor action, palate elevation and vocal cord action, but there is much overlap. In patients of all ages these nerves are examined by the eliciting the gag response by stimulation of the pharyngeal wall. The gag response demonstrates constriction of the pharyngeal musculature and elevation of the palate by the levator palatini muscle. Older children can also detect and report the sensation produced by stimulating the pharyngeal wall. The clinician can also note pharyngeal constrictor function by observing swallow. This is particularly useful in newborns and infants. During speech the vocal cord phonatory function is noted for vowel sounds, and nasal pharyngeal closure is examined when vocal sounds are made which maximally elevate the palate, such as the word "key". Hypernasality of speech indicates an incomplete separation of the nasal and pharyngeal cavities during palate elevation.

Cranial nerve XI (spinal accessory nerve)

This nerve innervates the sternocleidomastoid and trapezius muscles. The clinician evaluates the sternocleidomastoid by having the patient rotate the head to the opposite side against resistance; at the same time the contracting muscle can be palpated. Trapezius strength is evaluated by having the patient shrug the shoulders up against resistance. These muscles are also involved in head flexion and extension. In the newborn sternocleidomastoid strength can be indirectly evaluated by observing head flexion on the traction response (lifting the head and trunk from supine by pulling the arms) and by observing the resting head posture and spontaneous head rotation. In older infants and children, resistance to head rotation gives some indication of sternocleidomastoid strength.

Cranial nerve XII (hypoglossal nerve)

This nerve provides motor control to the tongue. In patients of all ages, the clinician notes the position of the tongue at rest and on protrusion. A protruded tongue deviates to the weaker side. Tongue movements are tested by observing the patient produce lingual speech sounds such as "takataka" and "lalala". The patient is asked to move the tongue from side to side very quickly and to push the tongue into the inside of the cheek against resistance applied by the examiner's finger on the outside of the cheek. The tongue should be examined when it is totally at rest for evidence of fibrillations or fasciculations.

As the newborn sucks on the examiner's finger, lingual tone, movement and strength can be gauged.

Speech assessment

Once the child has developed the ability to talk, spontaneous speech should be observed. A more cooperative child can repeat phrases and sentences for speech assessment. Infants initially coo, then babble, and then say single words, some of which may be intelligible. Speech is assessed for its clarity, accuracy and rhythm. Immature speech has characteristic substitutions of certain sounds such as "w" for "r" in "wabbit". If there are other abnormalities of articulation and no structural explanation (e.g., cleft palate), an attempt should be made to localize the neurological deficit. Abnormalities of the cranial nerves VII (labials), X (phonation and nasopharyngeal closure), and XII (lingual function) can produce characteristic speech abnormalities. Dysarthria, or slurring of speech, generally is due to cerebellar or extrapyramidal disorders. Cerebellar speech is typically a telegraphic or scanning type of speech, whereas extrapyramidal disorders produce a monotonous slow speech with poor breath control. Speech abnormalities must be distinguished from language abnormalities.

MOTOR EXAMINATION

In the child of any age the motor evaluation should begin with observation of the patient's posture and spontaneous movements. Lack or asymmetry of movement can be a manifestation of abnormality. The assessment of function of the newborn infant or young child occurs within the context of the expected age-appropriate motor abilities. By age six years, the motor performance of normal children should include most of the repertoire of a mature nervous system, but not necessarily the skill and facility.

Posture

The clinician should inspect posture with infants in a supine and sitting position and with older children also in the standing position. The normal posture of the preterm infant is one of extension, whereas that of a full-term infant is one of flexion of the extremities. In younger children who are beginning to sit, there is some slumping forward, which improves with maturation. In older children there is the tendency for a lordotic posture during standing, which also improves with maturity. There should be no asymmetry, and the sitting and standing posture should be erect. When older children are asked to hold the arms horizontally outstretched in front of the body with the hands supinated, they should hold the arms steadily and symmetrically. Pronation and downward drifting of one of the limbs indicate motor impairment on that side (pronator drift).

Several other postural abnormalities may be apparent. In the newborn the "frog-leg" posture in which the legs are externally rotated and abducted at the hips with flexion at the knees is frequently seen in profound weakness such as with anterior horn cell disease. Slumping of the child in a sitting position can indicate motor dysfunction at several areas of the nervous system. Head posturing can be associated with a variety of local or neuropathological processes, or both. Excessive lumbar lordosis may indicate weakness

of the muscles of the girdle or spine. A variety of postures are sufficiently characteristic to be recognized. The decerebrate posture with opisthotonus and extensor posturing of the limbs and the decorticate posture in which there is flexion of the upper limbs are fairly well known. The typical hemiplegic posture with flexion at the elbow and wrist and internal rotation of the arm along with extension of the leg on the hemiplegic side is also readily recognized. Mild forms of this type of posture or a tendency to assume this posture during activities such as walking can be a sign of mild hemiparesis. In younger infants the "scissoring" posture of the legs is due to increased adductor tone and crossing of the legs and is frequently seen in children with spastic diplegia. Dystonia can result in unusual postures at the neck, spine and limbs, but these characteristically are quite variable and changing. The posture of internal rotation of the arm and cupping of the hand ("waiter's-tip" position) is characteristic of lesions of the upper brachial plexus (Erb's palsy).

Muscle Tone

Muscle tone is the palpable resistance to movement, that is experienced by the examiner when the limbs or spine of the patient are passively manipulated by the examiner. Tone may be normal, increased (hypertonia) or decreased (hypotonia). Flaccidity is the complete absence of tone and it is always accompanied by weakness if not total paralysis. To assess tone, the patient should be at rest, offering no voluntary resistance or help while the examiner actively moves the joints through their range of motion. Tone reflects the resting neural activation of the agonist-antagonist muscle groups. In addition to range of motion, muscle tone can be tested by observing the inertial lag of the limb when it is suddenly displaced by the examiner. This test is conveniently performed in a supine patient by lifting the knee up quickly and observing the position and movement of the heel, which should normally stay on the surface. In hypertonia there is failure of the leg extensors to relax quickly, and the heel lifts off the surface. The clinician can also assess tone in most limbs by observing the motion of the unsupported part of the limb when it is shaken in a flapping motion. "Flappability" is increased in hypotonia and decreased in hypertonia.

During early development the tone of the normal infant changes considerably. The resting tone and resting posture are interrelated. The posture of the newborn preterm (age 28-30 week gestation) is one of extension and as the gestational age of the newborn increases to full term (40 weeks gestation) there is a progressively increasing flexion posture. The limb tone is decreased in the preterm progressing to increased flexion tone in the full term newborn. Tone in the newborn is also assessed by range of movement tests such as the scarf maneuver in which the extent to which the arm can be gently pulled across the chest to the opposite side is determined. The degree of extension of the leg (popliteal angle) dorsiflexion of the foot and other maneuvers are also used to assess tone (and gestational age) in newborn infants. Muscle tone in the newborn can also be judged by assessing the degree and speed of limb recoil from an extended position after it is released. Shaking of the arm or leg by the clinician while he or she observes the amplitude of movement of the more distal hand or foot (flappability) is particularly useful in the newborn and young infant. The flexed tone and posture of the newborn gradually decreases until normal mature tone is seen by about the age of 6 months. In addition to

appendicular tone, the clinician can assess axial tone in the infant by supporting the trunk in ventral suspension and observing the position of the infant draped over the suspending hand. The examiner also observes the head and trunk posture and movement when the infant is held in an upright sitting position. These maneuvers and the traction response assess active tone (power) as well as passive tone. The clinician elicits the traction response by grasping the hands and pulling the supine infant to a sitting position while observing normal head support (or head lag) and normal reflex contraction of the biceps. In the very hypotonic (or weak) infant, care must be taken to avoid injury by excessive movement of limbs or head during these tests. In infants there can be a discrepancy between axial and appendicular tone. It should also be remembered that tone can be markedly influenced by drugs, stress, excitement or systemic illness.

Hypertonia is abnormally increased tone which usually is a sign of central nervous system abnormality. In children this condition is frequently spastic hypertonia, and this is characterized by a velocity-dependent increase in tonic stretch reflexes (muscle tone). If the limb is passively moved slowly the resistance is less, but if it is moved more rapidly there is correspondingly increased resistance (tone) until a sudden lessening occurs (clasp-knife response). Spasticity is due to an upper motor neuron abnormality, but it does not equate precisely with cortical spinal tract disturbance, as is often assumed.

Rigidity is muscle hypertonia and stiffness appreciated as a persistent resistance to passive movement throughout the range of movement. Plastic rigidity is increased resistance in both agonist and antagonist muscles which is not velocity dependent. Its presence often is an indication of extrapyramidal or basal ganglia dysfunction. Nuchal rigidity, with stiffness of the neck and resistance to neck flexion, frequently is a reflex rigidity due to meningeal irritation. Extension of this rigidity into the musculature of the spine produces opisthotonus, which is primarily a form of extensor rigidity. Decerebrate rigidity results from the release of brain stem centers from higher control. This type of rigidity is a sustained muscle contraction of antigravity muscles, with the spine and all four limbs being rigidly extended.

Rarely hypertonia is due to peripheral mechanisms that result in continuous muscle fiber activity (neuromyotonia) or impaired and delayed muscle relaxation following contraction (myotonia). Myotonia can be demonstrated by the inability of the patient to release a handshake quickly or may be elicited by the percussion of muscles, producing an exaggerated contraction. This percussion myotonia can be elicited from several muscles, including the tongue, but perhaps the most dramatic, is percussion of the belly of the opponens pollicis muscle in the thenar eminence, which causes sustained contraction of this muscle for several seconds.

Hypotonia should be characterized by degree (mild, moderate, or severe) and distribution (focal, axial, appendicular, or generalized). The distribution has little localizing value, unless it is focal. Hypotonia can be associated with dysfunction of virtually any part of the central and peripheral nervous system or musculoskeletal system. Still, an attempt should be made to determine however whether the hypotonia is central (related to central

nervous system pathology) peripheral (related to peripheral nervous system pathology) or both. Associated neurological manifestations, such as altered reflexes, are helpful in making this distinction.

Muscle bulk and power

Muscle bulk should be evaluated using inspection and palpation. The degree and distribution of atrophy, absence, hypertrophy, or pseudohypertrophy of muscle should be noted. The presence of atrophy suggests decreased innervation, particularly if it is focal atrophy. Absence of muscle is generally a developmental abnormality. Hypertrophy may indicate overuse, overgrowth or underlying muscle pathology. Pseudohypertrophy describes the selectively enlarged but weak muscles seen in disorders such as Duchenne's Muscular Dystrophy. It is difficult to judge muscle bulk in newborns and young infants because of the large amount of adipose tissue on the limbs at this age. The tongue, however, is a muscle in which bulk is more easily assessed. Atrophy or hypertrophy may be prominent in this muscle when it is not apparent in others.

Power or strength can be determined in the older child using the formal Medical Research Council of U.K. (MRC) scoring scale, in which power is graded from 0 to 5. The grades are as follows:

- 0 - no contraction
- 1 - flicker or trace of contraction
- 2 - active movement with gravity eliminated
- 3 - active movement against gravity
- 4 - active movement against gravity and resistance
- 5 - normal power.

It is customary to use 4-, 4 and 4+ to indicate movement against slight, moderate and strong resistance.

Individual muscles or muscle groups should be formally tested when indicated. For routine neurological examination in infants and children a greater emphasis is placed on functional strength and how patients use this in various muscular activities of their own bodies. The activities of standing up from a supine position, walking, hopping, pulling away, "making a muscle" and squeezing an object can be easily understood by the patient and their observation by the clinician can provide a fairly good indication of the patient's strength. In infants and young children, strength is often estimated by the power of withdrawal from a noxious stimulus or away from the examiner. Assessment of active tone, such as by observing head support in ventral suspension, when the patient is held in a sitting position and during the traction response, will indicate power as much as tone. The older infant can be observed holding the head up in the prone position (2 months), then crawling and later walking (12-15 months). As children become older they can be expected to cooperate more and more with formal testing. By age 4 to 6 years, the normal child can cooperate well enough for a good assessment of power to be obtained. In older children, detailed muscle strength testing can be performed using the MRC scale with individual muscles when indicated.

In younger children and as a screening neurological evaluation in older children, tests of function can provide a gross estimate of strength in several muscle groups at once. During the first year the clinician can observe the functions of reaching (4 to 5 months), sitting when placed (5 to 7 months), crawling (9 to 12 months), and pulling to stand. Asymmetry of muscle function is also noted. After the age of 1 year, walking, running and then climbing can be observed. At around the age of 3 years, the young child may begin to ride a tricycle. At age 4 years, hopping with both feet and, at age 5 years, hopping on one foot may be possible. Strong preference for using one hand in infants younger than 1 year of age suggests weakness or other impairment of the opposite side. Useful information about motor function can also be obtained from observing how the uncooperative child actively resists the examination or holds on to items that are being retrieved.

Coordination

Coordination is the smooth integration of all elements involved in the accurate and efficient performance of movement. Incoordination is seen in pyramidal and extrapyramidal disorders of motor control, in sensory abnormalities and in cerebellar disturbances. Ataxia is incoordination not due to weakness, altered tone or involuntary movements. The most important form of ataxia, cerebellar ataxia, is due to disturbance of the cerebellum and/or its afferent or efferent pathways. Sensory ataxia refers to the ataxia due to altered sensory feedback regarding motion and position of the limbs. Coordination is tested through the examination of the speed, regularity and accuracy of movement. It is difficult to evaluate in the infant until sufficient voluntary control has developed, such as the ability to reach for objects (4-5 months). Coordination is formally tested in the limbs and trunk and during walking.

The finger-to-nose test in the upper extremity and the heel-to-shin test in the lower extremity are used to evaluate the ability to stop on target rather than bypass the target or miss it altogether. Loss of this ability, dysmetria, is a form of ataxia. The patient is instructed to rapidly touch the tip of the finger to two targets alternately, namely the examiner's finger, which should be moved to different positions during the test, and the tip of the patient's nose. Other targets may be used. This test may also bring out another sign of cerebellar dysfunction, intention tremor, in which as the patient's finger approaches the target it oscillates with increasing amplitude. The heel-to-shin maneuver is most easily performed when the patient is in a supine position. The patient is instructed to raise one leg and bring the heel of the foot of that leg down accurately onto the knee of the resting leg and, after touching it, move the heel smoothly down the shin to the foot and back again. This maneuver is done several times, and the smoothness and accuracy of the movement from the knee down to the foot are observed. In cerebellar disease this movement will be slow and irregular and the heel may fall off the shin. Having the patient perform these tests with the eyes closed also allows the clinician to evaluate for sensory ataxia. In the young child reaching for an object or touching a light or other interesting target can substitute for the finger-to-nose test. The clinician can also ask the child to touch various parts of their body, such as the nose.

The impairment of rapid and alternating movements due to cerebellar abnormality is dysdiadochokinesis. The clinician can evaluate for this abnormality by observing the speed, accuracy, rhythm and regularity of any repetitive movement. The usual tests for dysdiadochokinesis are rapid finger-to-thumb tapping, patting movements of the hand, toe tapping and the more complex movement of patting something with the palm of the hand and then the dorsum of the hand in an alternating pronation-supination movement.

The aforementioned tests measure coordination in the extremities. Unsteadiness of the patient standing or sitting is referred to as truncal ataxia, and this is frequently seen with caudal vermis abnormalities. The clinician observes the patient while he or she is sitting and standing and with and without the arms extended in front and notes the patient's inability to hold a steady position. When the patient is standing he or she may have a wide based stance. In older children, a more sensitive test is standing on one leg.

Abnormal movements

A variety of abnormal movements occur in children and, less frequently, in infants. The movements are usually involuntary and are abnormal in their pattern or time of occurrence in relation to normal voluntary movement. The dyskinesias include tremor, tics, myoclonus and the involuntary movements of chorea, hemiballismus, dystonia and athetosis. Ataxia, epileptic movements, fasciculations, hemifacial spasm and sleep associated movements, while involuntary, are by convention considered under other categories of neurological abnormality. Repetitive movements such as mannerisms, self-stimulation and stereotypies are not considered to be motor abnormalities. The clinician assesses for dyskinesias by observing the patient at rest and during voluntary action. Since these movements are usually obvious on visual inspection, video technology is very useful for the clinician to document the degree and pattern of abnormality and for the caregiver to record those movements that occur intermittently or infrequently. Dyskinesias usually only occur when the patient is awake and frequently can be voluntarily modulated but not totally controlled.

The characteristic feature of tremor is rhythmical oscillation of a body part. In children this oscillation is usually seen in the upper extremity, or less commonly, the head. The clinician notes whether the tremor occurs mainly at rest, with sustained posture (e.g., with arms extended) or with action and whether the frequency is greater or less than 6 Hz. The patient should be asked to copy a spiral or other figure and to write a sentence in order to demonstrate the effects of the tremor on these fine motor activities. Myoclonus is a sudden, brief involuntary contraction of a muscle or group of muscles. Myoclonus produces a movement that is not synergistic or stereotyped. Tics are sudden, repetitive, synergistic, stereotyped movements which may be simple, complex or phonatory. Choreic movements are brief, arrhythmic, asymmetrical and synergistic; they appear to be fragments of normal movements. Hemiballismus is a severe form of chorea with large amplitude movements involving an entire limb. Dystonic movements are characterized by sustained muscle co-contraction of agonist and antagonist muscles. The abnormal muscle activity in dystonia produces twisting movements or abnormal postures. The movements and postures of dystonia typically fluctuate during the examination.

Athetotic movements are more rapid and the postures are more transient than dystonia. Speech is affected more often in athetosis than in the other dyskinesias. The clinician should observe for abnormal movement in the child in different positions at rest and while performing voluntary movements, such as walking, extending the arms in front and reaching for objects.

Gait

Before the infant begins to walk there is a period of time when “cruising”, or walking with support, occurs (11-13 months). Asymmetries can be noted at this stage. Initially there is hesitancy and unsteadiness, which progresses to a wide-based "toddlers gait" as part of normal maturation. Specialized variations of the gait, such as running and climbing stairs, provide additional dimensions to the gait assessment. In the older child, associated movements such as arm swing should be noted, particularly for the presence of asymmetry. The base, size and speed of the steps and the posture should be noted during gait observation. The ability to independently ambulate and the use of walking aids is recorded. The sounds of the footfall, particularly with the shoes on, can provide additional information, but gait should generally be observed with the patient barefoot as well. Excessive wearing of one shoe sole or part of the sole on one or both feet can indicate abnormal gait.

Several gaits are characteristic of neurological impairment. The hemiplegic gait has some degree of foot drop and circumduction, or lateral swinging movement, of the foot. The spastic paraparetic or tetraparetic gait is a bilateral shuffling gait with a tendency for the legs to pull together in adduction (scissoring). There can be a tendency to walk on the toes, or the patient may walk in a crouched position. Gait ataxia frequently is related to rostral cerebellar vermis dysfunction. The patient has difficulty in maintaining a narrow-based gait and spontaneously may have a wide-based gait. Most normal children over the age of five years can perform tandem gait with one foot directly in front of the other in the midline with toe touching heel. Children are able to walk on a narrow path before they are able to walk tandem. Narrow path walking should be tested if the patient is too young to perform the tandem test. The ataxic gait is wide-based and unsteady, with staggering, lurching, or swaying. Tandem walk is particularly difficult. A unilateral ataxic gait produces much less disturbance, but there may be a tendency to deviate to the ataxic side. The waddling gait of girdle weakness is due to weakness of the gluteus medius bilaterally, causing a pelvic instability that leads to an exaggerated vertical movement of the pelvis with gait, producing the waddling appearance. Foot drop results in scraping of the toe on the floor or a steppage gait in which there is compensatory, excessive lifting of the lower extremity with the foot being swung forward and slapped down to prevent the toe from dragging. This type of abnormality may be unilateral or bilateral. The antalgic gait results from the patient's attempts to avoid pain by performing maneuvers to limit the time that weight is put on the affected side during walking.

REFLEX TESTING

Reflex testing is very important in the pediatric examination because it does not require conscious or voluntary responses or even cooperation. Many primitive reflexes are

described in the section on neonatal examination. Of the others, there are stretch reflexes, superficial reflexes, and pathological reflexes.

The muscle stretch reflexes or deep tendon reflexes are evoked by stimulation of sensory organs in the muscle by stretch. In these reflexes there is a reflex contraction of the muscle being stretched. These reflexes are easily elicited in newborns and young infants with the tomahawk style percussion hammer or a miniaturized version of the Queen's Square or other reflex hammers.

The jaw, or masseter, stretch reflex (testing the trigeminal nerve) is readily seen in the newborn infant but may be difficult to elicit in the older child. The clinician elicits this reflex by placing his or her index finger horizontally over the chin of the patient's slightly open and relaxed jaw and then tapping the index finger. This causes a stretch of the masseter muscle, and the reaction is a contraction of that muscle. Newborns may demonstrate clonus with this maneuver, which may be normal or an indication of a corticobulbar abnormality.

Maneuvers to elicit the biceps reflex (C5-6, musculocutaneous nerve), the brachioradialis reflex (C5-6, radial nerve) and the triceps reflex (C7-8, radial nerve) are performed on the upper extremity. The method is the same for infants and older children. The examiner percusses his or her thumb or finger placed over the biceps tendon at the antecubital fossa for the biceps reflex. Percussion of the brachioradialis tendon near the styloid process or of the triceps tendon just proximal to the olecranon may be done directly with the hammer or indirectly through the overlying digits of the examiner. Also, percussion of the examiner's fingers overlying the slightly flexed distal fingers can elicit the finger flexor reflex (C6-T1, median and ulnar nerves). Maneuvers to elicit the patellar reflex (L2-4, femoral nerve), the ankle reflex (L5-S2, tibial nerve) and the adductor reflex (L2-4, obturator nerve) are performed in the lower extremity. The patellar reflex is elicited by percussing the subpatellar tendon with the knee slightly flexed thereby producing a quadriceps muscle stretch and then contraction. The ankle reflex is elicited by tapping the Achilles tendon, producing a contraction of the gastrocnemius, soleus and plantaris muscles, and the adductor reflex is elicited by tapping the adductor tendon near the medial epicondyle of the distal femur, producing adductor muscle contraction.

Reflexes are graded from 0 to 4+, with an absent reflex being 0, normal reflex 2+, and hyperactive reflex 3 or 4+. If there is reduplication of the reflex or if clonus is elicited by the testing, then the reflex is generally considered 4+. It may be possible for the examiner to elicit otherwise undetectable reflexes by using the Jendrassik maneuver, in which the patient clasps the fingers of both hands together and attempts to pull the hands apart at the same time the reflex is tested. A similar reinforcement may be possible if the patient makes a very tight fist of both hands or clenches the jaw at the same moment the reflex is tested. In addition to grading the reflex, the clinician should note the spread of reflex to adjacent joints as a sign of increased reflex activity. The crossed adductor response is elicited on patellar testing. When this reflex is present, the contralateral adductor also contracts. This is also evidence of increased reflex activity.

The superficial (cutaneous) reflexes are present in young children. The abdominal reflexes are elicited by stroking the upper and then lower quadrants of the abdomen. The reflex consists of a contraction of the abdominal musculature beneath the stimulus usually resulting in a movement of the umbilicus towards that quadrant. A slightly blunted stick such as a split tongue depressor is effective as stimulus. If the object is too blunt there will not be a reflex elicited but the stimulus should not be painful. The superficial abdominal reflexes are mediated by the nerve segments that innervate the abdominal wall, approximately T7-T10 in the upper quadrants and T11-L2 in the lower quadrants. These reflexes disappear after certain upper motor neuron lesions have occurred.

The cremasteric reflex is elicited by stimulating the skin of the upper inner thigh and observing the contraction of the cremasteric muscle resulting in ipsilateral elevation of the testicle. This reflex is innervated by L1-L2. The bulbocavernosus reflex is sometimes useful. Stimulation of the dorsum of the glans penis causes a palpable contraction of the bulbocavernosus muscle as well as the external anal sphincter. The bulbocavernosus reflex is mediated by nerve segments S3-S4. Anal tone can conveniently be assessed at the same time. The cutaneous anal reflex is a contraction of the external anal sphincter in response to stroking or pricking the skin or mucous membrane in the perianal region. This can be seen as a contraction of the anus (anal wink) with that stimulus. This reflex is mediated by nerve segments S2-S4.

Pathological cutaneous reflexes include the classical Babinski sign and other reflexes that elicit an extensor response of the great toe. These have various eponyms. The stimulation for the Babinski response is a somewhat noxious stroking of the plantar surface of the foot from the heel forward. The normal response is a plantar flexion of the toes, particularly the great toe, but this is not always seen. The abnormal response is a dorsiflexion or extensor response of the great toe and fanning of the other toes. This reflex is mediated through the tibial nerve and involves nerve segments L4-S2. In order to avoid a grasp response with flexion of the toes in the neonate, it is often better to stimulate from the toes downward to the heel. Extensor responses of the toe are frequently seen in normal newborns and young infants during the first year of life, but the quality of these responses seems different from the usual Babinski sign. Nevertheless, an important aspect is asymmetry of response between the two sides. Another response that is sometimes seen in comatose or paraplegic individuals is the triple flexion response, in which stimulation of the sole of the foot gives rise to dorsiflexion of the toe, flexion of the knee and flexion of the hip. This is a spinal-mediated response, and its presence does not indicate voluntary withdrawal.

Withdrawal is often seen when the Babinski sign is elicited in children. Sometimes this response can be minimized by simultaneous elicitation of the Oppenheim sign, which produces a Babinski-like response but is elicited by heavy pressure with the thumb and index finger on the anterior surface of the tibia stroking from the knee to the ankle. Another maneuver, that may minimize withdrawal, is flexion of the hip and knee and dorsiflexion of the foot in infants or children prior to eliciting the Babinski sign. Some clinicians are concerned that this may inhibit a valid Babinski response when one is

present. The Gonda sign is the elicitation of the Babinski sign by flicking the distal tip of the second or fourth toe. This can be useful when there is a cast on the foot.

Clonus is a reflex response that indicates hyperreactivity of the cortical spinal tract. This can sometimes be normally seen in the newborns or young infants, but it would not generally be sustained. Ankle clonus is elicited by rapid and sustained dorsiflexion of the foot by the examiner when the leg is slightly flexed at the knee. Rhythmical alternating contraction and relaxation of the gastrocnemius muscle produces rhythmical ankle plantar flexion movements against the examiner's hand. This reflex is usually elicited most easily by a rapid stretch, but it may require several repetitions to elicit the clonus. The clonus may be either unsustained in which case it attenuates, or sustained, in which case it is maintained for many seconds or indefinitely. Clonus may be seen spontaneously when the patient places the foot in certain positions. Clonus can also be elicited from other sites, and the mechanism is similar.

DEVELOPMENTAL REFLEXES

Near-term premature infants, full-term neonates, and young infants have many reflexes that disappear with time or are replaced by voluntary movements and cannot be elicited in the older infant. The Moro response, seen in pre and full term neonates, disappears by the fifth or sixth month of life. The infant's head and body are held and the head is allowed to drop quickly a very short distance before being gently supported again. In response to this and other maneuvers that suddenly displace the head and trunk relationship, there is a sudden extension and abduction of the upper limbs with opening of the hands. These responses are immediately followed by a flexion and adduction of the limbs toward the midline. The Moro response reflects the general level of excitability of the infant's nervous system; an infant with a depressed nervous system, for example, shows a decreased or absent response. Asymmetry of response can also be significant and usually indicates a peripheral problem (e.g., Erbs palsy, fracture of the clavicle). In the less responsive newborn some indication of the level of nervous system depression can also be determined by the nasal closure response. Lightly pinching the nostrils together briefly elicits an extensor posturing of the arms in the normal newborn. This response may persist even when the Moro response can no longer be elicited in the neonate with a severely depressed nervous system.

Premature and mature newborns and young infants demonstrate an involuntary grasp response. This reflex persists until the time that they begin to make voluntary reaching movements (three to five months), and then it gradually diminishes and is replaced with a voluntary grasp. The clinician elicits the grasp response by putting his or her finger into the palms of the infant's hands or the soles of the infant's feet, producing involuntary closure of the infant's digits around the finger. In the foot the toe grasp may persist until later in the first year. The sucking reflex is a robust primitive response that reflects the level of excitability of the infant's nervous system as well as oral function. This reflex can often best be estimated by use of a gloved finger. The vigor and degree of suction and the absence of an abnormal biting movement should be noted as the infant suckles the finger. The effectiveness of an infant's sucking can also be observed during bottle-

feeding, which offers the opportunity for evaluation of swallow as well. The clinician tests for the rooting response by stimulating the lateral margins of the infant's lips and noting an orientation and turning of the face and mouth to the stimulus in an attempt to suckle it. This reflex, which requires intact face sensation, disappears as the nervous system becomes depressed.

The traction response is elicited by taking the supine infant by the hands and pulling him or her up to a sitting position. The response is a flexion of the arms and a stabilization of the head. Head lag and lack of arm flexion are abnormal responses. The placing response is elicited by holding the infant vertically and bringing the dorsum of the foot and leg up to the edge of a tabletop or a bed rail. The limb is flexed, then pulled forward and extended almost as if the infant is stepping over the obstacle. This reflex diminishes during the second half of the first year. The supporting reaction is variably present in the first 6 months. The infant is held erect and lowered so that feet touch a surface. When the supporting reaction is present, the infant extends the leg and supports his or her weight somewhat. The stepping response is elicited by holding the infant erect, and then leaning the infant forward with the feet lightly touching the surface. The response is a stepping forward movement of the legs, which may continue for several steps. This reflex is often present during the first 6 weeks of age, but it can be seen later in some infants.

When the infant is held in a horizontal prone position (ventral suspension), the truncal incurvature response (Galant) can be elicited by superficial stimulation of the back along the paraspinal musculature (birth-2 months). This stimulation causes a twisting and curving of the body toward the stimulus. This reaction should be compared on both sides. The Landau response is also elicited with the infant in ventral suspension. A normal infant has some extension of their head and legs in this prone position. Flexion of the head results in flexion of the hips. This response appears around 3 months and persists throughout infancy.

The tonic neck response may normally be present in the first 4 or 5 months of life and is most easily elicited between 2 and 4 months. Turning of the head to one side produces a tendency for flexion of the limbs of the contralateral side and extension of the ipsilateral limbs. Rotating the head back to the other side causes a reversal of this posture to its mirror image. The normal response is never obligate, persistent past 6 months or significantly different from one side to the other. There is a persistent or obligate posturing of the flexed arm on the side of an existing hemiparesis. With maturation, the tonic neck response is replaced by the neck-righting reflex in which the infant's body and limbs automatically follow when the head is turned to the side as the patient attempts to roll over. This normal response becomes obvious around the ages of 4 to 8 months when rolling over develops.

The clinician elicits the parachute response by holding the infant in ventral suspension and moving the body downward rapidly. The reflex is an extension of the arms forward as if to break a fall. This response will appear at age 8 to 10 months in all normal infants. The clinician should note its presence and any asymmetry, which may indicate the

presence of a hemiparesis or other motor abnormality.

SENSATION

The sensory system includes the primary modalities of pain and temperature, touch, proprioception and vibration of the somatosensory system and the higher cortical processes of perception and discrimination of more complex sensory stimuli. This system also includes special senses such as smell, vision, taste and hearing which are evaluated during the cranial nerve examination. The normal child of 5 or 6 years should be able to cooperate for a fairly complete sensory examination. Since a refined examination depends upon the subjective and qualitative judgement of the patient, the examination must be cruder and more creative in the younger child.

In the newborn somatosensory examination, virtually all that can be assessed is response to pain or to tickle, which are probably mediated by similar pathways. When the clinician tests for pain sensation in a patient of any age, a clean sharp stick that is disposed of after the examination is preferable to a pin, which can transmit disease, or to a sterile needle, which often draws blood. This stick is used to test cutaneous pain sensation. Deep pressure over bones or tendons can cause diffuse aching (deep) pain, which is less well localized but can be used to test the level of responsiveness of the individual. For any age of patient, the clinician tries to determine the location of the sensory abnormality and whether it has the pattern of dermatome (segmental) or nerve distribution. In the older infant, tickle is preferable to painful stimulation during the initial stages of the examination. One observes whether the infant notices a touch or tickle that is performed surreptitiously. The infant may look at the stimulus or brush it away. In some older infants, it is also possible to recognize a response to a vibratory stimulus. The clinician places the stem of the tuning fork on the extremity when the fork is not vibrating and allows the infant to adapt to this, then the examiner notes the response of the infant to the initiation of vibration while the fork is still in place on the limb.

In older children the examination can be more formal. Response to pain is usually tested with a sharp disposable stick, but response to tickle can be used in the overreactive and oversensitive child. In an otherwise normal child with no sensory complaints, a screening test with detection and comparison of response to a sharp stick distally in the feet and in the hands, and comparison between distal and proximal responses, may be all that is required. Any indication of spinal cord abnormality requires a detailed search for a sensory level. The sharp stick is touched and quickly withdrawn, with the clinician taking care to apply the same pressure with each stimulus. The cooperative patient is asked to report whether the stimulation is sharp or dull or of quality and sharpness different from that of the comparison stimulus. It is preferable to move from an area of loss or lesser sensation to the normal area to detect a change, the location of which is then marked on the skin. In the extremities the sensory loss may be peripheral in a stocking-glove distribution, or may follow the distribution of a root or nerve. There is much overlap between adjacent dermatomes, which may make minor sensory losses difficult to identify.

In less responsive individuals deep pressure over bone, tendon or nail bed can produce a noxious and painful stimulus that may be more arousing to the obtunded patient. This test is generally not useful in a conscious, cooperative child.

Temperature is mediated by the same pathways as pain and, when necessary, can be tested more formally with cold and hot tubes of water applied to the skin briefly to determine if the patient can detect cold or hot. Many examiners use, as a simple screening test for temperature, a cold metal object applied to the skin to see whether it is recognized as cold. The metal tuning fork is often used for this purpose. Pain and temperature are carried by afferent fibers with cell bodies in the dorsal root ganglion that enter the dorsal spinal cord and, after ascending several segments, cross over near the central canal to spinothalamic tracts in the lateral part of the cord and ascend to the thalamus.

Touch or tactile sensibility is tested with a wisp of cotton or a paper tissue. This stimulus must be a touch and not a moving or wiping stimulus, for such stimuli activate other neural pathways. With the patient's eyes closed it is useful to ask the patient to touch where the examiner has touched. This approach assures that the stimulus was detected and also provides a higher cortical assessment of point localization. Children are encouraged to view this type of examination as a game, and this is reinforced with praise when they succeed. Alternatively the patient can be asked to say "now" whenever the stimulus is felt. Patients can either consciously or subconsciously alter the results of the sensory examination. In that event, repeat testing will usually show discrepancies in the location of sensory loss. Other strategies such as having the patient say "yes" when he or she feels it and "no" when he or she does not are sometimes revealing. Again, the comparison of sensations is made between peripheral and proximal, between left and right, between levels of the trunk and between the different sides of an extremity. The cooperative patient can give a subjective assessment of qualitative differences between two stimuli that are both detected when one is testing in an area of deficit. Fibers carrying tactile or touch sensibility enter the zone of Lissauer and synapse with neurons in the dorsal horn. Tactile sensibility utilizes two pathways. One of these pathways crosses over near the central canal to the opposite side and ascends in the ventral spinothalamic tract to reach the ventral posterolateral nucleus of the thalamus. The other pathway follows the dorsal column ipsilaterally, then crosses over to the opposite side in the medulla, and terminates in the ventral posterolateral nucleus of the thalamus.

The sense of vibration is tested with a 128 Hz tuning fork, and most children can detect and recognize the stimulus. Older children are able to report thresholds. The stimulus is usually placed on the distal finger or toe but vibration can be tested over any bony prominence including the iliac crest, spinous processes, sternum and skull. In cooperative patients the test is usually done only distally, unless there are sensory complaints or findings. To detect a sensory loss, the threshold of the vibration stimulus is compared from distal to proximal, from left to right and with the same site on the examiner. So that the younger child can understand what is expected, the tuning fork is first placed on the digit without vibration. Very often the cooperative younger child will say "yes" to any stimulation including just the pressure of the tuning fork, and must be coached in proper discrimination. Vibration is mediated through large and medium-sized

myelinated nerve fibers and is believed to ascend the spinal cord in the dorsal columns ipsilaterally, but other pathways may also be utilized. Because the sound and the vibration produced by the tuning fork are compelling stimuli for some children it can be used as a novelty which can attract their attention and induce them to reach, touch or want to play with it.

Proprioception, or position sense, is not easily examined in infants and young children and is not usually tested. Older, cooperative children can be fully evaluated. Testing is done initially in the distal digits, usually the great toe and the thumb or index finger. The digit is held on either side of the joint to be tested, usually the distal joint. The proximal part is held fixed while the distal part is moved in extension or flexion during the testing. The digits are held on the side so as not to provide pressure clues on the direction of movement. The clinician demonstrates the motion to the patient, indicating which direction is up or down (or forward or backward), so that both examiner and examinee agree on this point. Alternatively, the patient can indicate the direction of movement by pointing. Small-amplitude, single movements are made in one direction, with the patient's eyes closed, to see whether he or she can detect movement and, if so, the direction of the movement. The amplitude of excursion required for detection can be used to quantitate the response. A series of movements in random directions are done until the examiner is convinced that the patient is accurately identifying the direction. Proprioception on left and right sides should be compared and testing of the toes should be compared with that of the fingers. If a deficit is found, then the clinician should test the same limb at a joint more proximal, similarly holding the limb proximal and distal to the new joint being tested.

Proprioception also is indirectly tested during other parts of the neurological examination. Thus, on finger-to-nose testing done with the patient's eyes closed, proprioceptive mechanisms are indirectly being evaluated. Testing for the Romberg sign also assesses proprioception. Even younger children can cooperate with this test, in which the child stands with feet as close together as he or she can bring them and still maintain a steady stance and then closes the eyes. permits a steady stance and then closes their eyes. If there is increased swaying or falling when the eyes close, the Romberg sign is positive, indicating a sensory abnormality, often in peripheral nerve or dorsal columns, that affects proprioception.

Testing of higher cortical sensory perception and discrimination (gnosis) can be done as part of the mental status examination or the sensory examination. Most of these tests are usually only possible in older children or very cooperative younger children. The tests measure contralateral parietal lobe function. Point localization is a form of perception that can be tested as part of the routine examination even in younger children because it is easy for them to understand the concept. As part of sensory testing one can ask the patient to "touch where I touched". This not only documents that the touch has been felt, but also measures how accurate their point localization is. Younger infants are not precise, but can localize touch to the approximate vicinity of the stimulus. Older children and adults should demonstrate very precise localization. Graphesthesia is easily tested at the bedside. Letters or numbers can be used. It is also often helpful to initially trace the

number or letter in the palm of the child's hand with a pointed object, while the he or she is watching, to ensure that the instructions are understood. If that seems acceptable, a different symbol is drawn with the patient's eyes closed to see if he or she can identify it. Younger children may not be able to recognize all numbers, but there should not be an asymmetry in the responses for the two hands. Stereognosis testing utilizes common objects such as coins, keys, safety pins, paper clips or small round balls. These objects are placed in the patient's hand, but they should not look at them and should be prevented from manipulating the objects with their fingers. If these objects cannot be identified, then finger manipulation of the item can be allowed, but the results will not be considered normal except in younger children. Comparison of the responses of the two sides of the body is most important. Testing for two-point discrimination is best done with the use of a special caliper manufactured for that purpose, but a paper clip can be readjusted to provide two tips whose separation can be varied. Distal fingers and lips are very sensitive in discriminating small separations. In older children a 3 to 4 mm separation should be readily detected. Again, comparison of the responses of the two sides is most useful.

EXAMINATION OF SPECIFIC AGE GROUPS

NEONATES AND YOUNG INFANTS

Examination of neonates (premature and full-term) or young infants is limited to observation, palpation and reflex testing, but it can generally be done without great resistance from the infants if they are not hungry or have other discomfort. The examination can be approached systematically, as in the older child and adult, or it can be coupled with the general physical examination if that is more convenient. The following should be evaluated and the sequence listed is one possible approach to the examination.

Any deformity of the face, head, spine or feet should be noted. The shape of the head and the dimensions of the anterior fontanelle dimension (from one frontal bone margin to the opposite parietal bone margin) should be recorded. The clinician should note the presence of separated sutures, posterior fontanelle, suture overriding or fusion and any palpable swelling such as a soft tissue caput or periosteal cephalhematoma. The blink reflex, pupillary reaction, and visual following and eye movements, (spontaneous and with oculocephalic reflex) are tested, and a funduscopic examination is performed. The corneal response to stimulation with a cotton wisp or puff of air, the sucking response, the jaw jerk and the rooting response are noted. Observing for facial contraction, including eyelid closure, may be postponed until the infant begins to cry. Testing for the gag response should also be deferred to the end of the examination. Sucking can be examined using a soother or finger stimulus. Sucking and swallowing may be evaluated during the infant's feeding. The response to a loud whistle or a bell should be noted. The grasp responses are tested, and the resting tone and posture are noted. The clinician should test for biceps, triceps and brachioradialis stretch reflexes in the upper extremity,

and the patellar and ankle jerk reflexes and the Babinski response in the lower extremity. The stepping, placing and supporting reactions as well as the truncal incurvature and Landau responses, are tested next. Testing for the infant's head support, Moro response, response to nasal closure and traction response can be done together. The clinician can test for the tonic neck and neck-righting responses in the older infant and the parachute response in the still older infant.

Testing of the sensory response to painful stimulation is best done at the end of the examination. A sharp stick should provoke arousal, a grimace or even crying depending on how noxious the stimulus is. Comparison of the responses from both sides of the head, body and extremities should be made and a sensory level should be sought, particularly if there is an obvious spinal malformation. The superficial anal reflex is then elicited, and if there is suspicion of a neurological deficit, the anal tone can be noted with a gloved finger.

Infants around the age of 4 to 6 months can hold on to objects that are handed to them and may even begin to transfer them from one hand to the other. There should be no preference for the use of one hand over the other at this age; if such preference is present this probably indicates a hemiparesis or some other abnormality. The clinician observes the older infant for lifting of the head when the patient is in the prone position (2 months), ability to roll over (4 to 6 months), sitting when placed (6 to 8 months) or moving into a sitting position independently (8 to 10 months).

OLDER INFANTS AND YOUNG CHILDREN

In this group the approach is different. The nervous system is not systematically examined, but the examination is recorded in the standard outline. This approach is most appropriate for those infants who have developed stranger anxiety (6-9 months). In older children a more systematic approach can be taken, as in adults.

Observation during history taking: The clinician can estimate the patient's mental status by reviewing the history and by observing the patient's interactions with parents, toys, the environment and the examiner, and by noting the patient's actions during feeding and playing. Note if the patient is alert and aware, visually attentive, socially interactive and comfortable or fearful. Observe the patient's response to the caregivers verbal stimuli, comments and requests and note the patient's level of speech. Observe how the patient performs complicated actions that require a certain level of cognitive development and sensorimotor ability. In order to perform many simple activities, the patient utilizes several neurological functions; therefore, these activities can constitute a gross screening test for dysfunctions in those systems (e.g., picking up a very small object requires a certain level of vision, a degree of fine motor control, and steadiness).

Hands-off examination: Without touching the patient the clinician can assess the child's visual fields, vision, eye movements and sometimes pupils. Facial movements during spontaneous smiling or crying can be noted and hearing can be checked. Head support and trunk support can be observed. The use of the limbs spontaneously in walking, in crawling, and in the manipulation of objects such as toys gives some indication of

coordination as well as motor control. It is often useful to hand the patient a toy or other interesting object, if this has not been done previously. If the patient refuses the object from the examiner, he or she may accept it from the parent. Playing with an item distracts the infant's attention so that he or she may overcome their fear of the examiner. As the patient reaches for the toy, the clinician further observes his or her motor control. Small blocks may be offered to the child and designs for arranging them can be suggested to see if the child can mimic these. A penlight can be used to play the "put out the light" game. The examiner demonstrates how the light can be extinguished by touching it and then the infant is invited to try the same thing. This game provides a very good approximation of elements of the finger-to-nose test. During these observations, handedness should be noted. The child's response to requests and the child's own speech is noted during this part of the examination as well. At the end of this stage of the examination, the infant may have walked or crawled, but if not, the parent or caregiver can put the infant on the floor or table to encourage this. Observation of how the infant rises from the floor to a standing position and then walks can be informative.

Hands-on examination: This examination can be done along with the rest of the general pediatric physical examination. There are two sections, the non-threatening examination and the possibly threatening examination.

Non-threatening examination: The clinician can check the infant's response to sensory stimulation by tickling or touching various parts of the body to see if the infant notices it. The face, particularly around the ears and nose, and the extremities are good areas to test with a wisp of cotton or tissue. Vibration from a tuning fork is often of interest to the infant, and the examiner can often tell from the patient's response that the vibration is detected. Reflex testing is usually non-threatening, and reflexes can be examined at this time as well as muscle tone. Strength can be tested as the infant pulls a toy away from the examiner, as the infant stands up, or as the infant withdraws from a tickle or perhaps noxious stimulus. The clinician should examine for cutaneous lesions, scoliosis and organomegaly at this time.

Possibly threatening examination: When the aforementioned examination has been completed, it is appropriate to examine the areas that were resisted by the infant. These and anything uncomfortable or noxious to the child would generally be postponed to this time, much as the examination of the ears might be postponed to the end of the general pediatric examination. Some infants allow a funduscopic examination fairly early and permit pupillary responses to be tested without complaint. Having an assistant or family member hold interesting objects behind the examiner often successfully directs the vision of the infant away from the ophthalmoscope. The clinician can test the gag response and observe palate and tongue movement and position in addition to pharyngeal contraction. Very often the infant facilitates parts of the examination by crying, at which time symmetrical facial contraction with good eye closure can be observed. The tongue and palatal position and movement can be noted as well during crying or vocalization. If gait has not been tested previously, the examiner should take the infant away from the parent and then observe how the patient crawls or stands up from the floor and walks or runs to the parent. If measurements such as head circumference have not previously been done,

they should be performed before the end of the examination. It may be best to postpone the measurement of head circumference until the end of the examination, since many infants do not like the sensation of the tape on their heads.

Table 1 - Language Development

Age	Behavior
4 months	<ul style="list-style-type: none">• cooing - vowel like sounds
6 months	<ul style="list-style-type: none">• babbling - 1 syllable sounds
8 months	<ul style="list-style-type: none">• responds to name
12 months	<ul style="list-style-type: none">• speaks at least one word responds to simple commands such as "no"
18 months	<ul style="list-style-type: none">• speaks more than three words knows two or three body parts
2 years	<ul style="list-style-type: none">• has two to three word sentence• follows two or three word commands• points to pictures as requested
3 years	<ul style="list-style-type: none">• speaks three - four word sentences• uses pronouns and plurals• knows age, sex and full name• asks questions
4 years	<ul style="list-style-type: none">• has four to five word sentences• can tell story• knows one color• uses past tense• responds to two part commands
5 years	<ul style="list-style-type: none">• responds to three part commands• has over five word sentences• uses future tense, knows four colors• counts ten or more objects• recalls parts of story

Ages at which most children achieve the language milestones.

Table 2 - Adaptive development

Age	Behavior
6 weeks	<ul style="list-style-type: none">• smiles responsively
3 months	<ul style="list-style-type: none">• follows visually 180 degrees
5 months	<ul style="list-style-type: none">• reach for object
6 months	<ul style="list-style-type: none">• holds one block/toy in each hand
9 months	<ul style="list-style-type: none">• has stranger awareness/anxiety
12 months	<ul style="list-style-type: none">• waves bye-bye, plays peek a boo, finds object hidden in presence
15 months	<ul style="list-style-type: none">• places one block on top of another, throws items
18 months	<ul style="list-style-type: none">• mimics examiner, finger feeds self, helps undress self
2 years	<ul style="list-style-type: none">• copies vertical line, builds tower of three blocks, uses utensil for eating, turns single book pages
2 1/2 years	<ul style="list-style-type: none">• copies horizontal line, completely feeds self
3 years	<ul style="list-style-type: none">• mostly dresses self, copies circle, builds tower with four blocks, produces horizontal line of blocks
3 1/2 years	<ul style="list-style-type: none">• plays interactively with other children
4 years	<ul style="list-style-type: none">• copies cross, draws person with two 2-4 parts, uses scissors, knows concepts of length, height or weight
5 years	<ul style="list-style-type: none">• copies triangle and square, draws a person with body
6 years	<ul style="list-style-type: none">• copies diamond

Ages at which most children can demonstrate listed behaviors.

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