Concise outline of the nervous system examination for the generalist

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ABSTRACT

Many students, residents and generalists consider examining the nervous system as one of the most difficult parts of the physical examination. Certain problems frequently face the junior physician including organizing a complete examination in a short period, and consistently eliciting the physical signs. Certainly, repeated examinations and experience play an important role, however, solid knowledge and use of proper techniques are crucial for eliciting and interpreting neurological signs. In this paper we present an outline for the examination of the nervous system based on the medical literature and author's personal experience. Various techniques of eliciting physical signs and possible pitfalls in the examination will be discussed.

Keywords: Nervous system, central nervous system, examination, pediatric, adult, outline.

Neurosciences 2001; Vol. 6 (1): 16-22

Neurological disorders are common in Saudi Arabia as a result of the high rate of inbreeding or consanguineous marriage.[1] Consanguineous marriage is usually a common traditional practice followed within the same tribe, village, or social unit.[2] This results in the high prevalence of many inherited neurological disorder, which may become more common in the future.[1] Diagnosing these disorders requires accurate assessment including detailed neurologic examination, which is an important step in formulating differential diagnosis and guiding laboratory investigations.[3]

Many students, residents and generalists consider examining the nervous system as one of the most difficult parts of the physical examination. Certain problems frequently face the junior physician including organizing a complete examination in a short time period, and consistently eliciting neurological signs.[3] Certainly, repeated examinations and experience play an important role, however, solid knowledge and use of proper techniques are crucial for eliciting and interpreting neurological signs. In one study, general practitioners working in primary care had less confidence in handling neurological patients than patients with other common medical conditions.[4] In another study, up to 54% of pediatricians referred more than 90% of their patients with neurologic complaints to neurologists.[5] These pediatricians showed a significantly lower self-assessment score than did other pediatricians in knowledge and skills in performing a neurologic examination.[5] Therefore, confidence in performing the nervous system examination appears to be critical in the proper evaluation and management of patients with neurological abnormalities.

Wide number of references is available regarding the administration of nervous system exam, however, a concise and simple outline is lacking. The approach and styles of different neurologists may vary, however, consistency in conducting the examination is critical.[3,6] In this paper we present an outline for the examination of the nervous system based on the medical literature and the author's personal experience. Neuro-anatomical and neurophysiological bases of various physical

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findings will be outlined. Differential diagnosis of some important signs will be presented. Various procedures and techniques of eliciting physicial signs and possible pitfalls in the nervous system examination will also be discussed.

Organization of the nervous system examination. If the examiner has a consistently organized approach to the nervous system examination, he or she will less likely miss important parts of the examination.[3,6] When we ask many students or residents to examine the nervous system, they frequently proceed to higher cortical functions, motor or cranial nerve examination. This is a common mistake, as the examiner should first assess aspects of the general examination of relevance to the nervous system before conducting the core exam. These areas include the vital signs, anthropometric measurements, and general examination. The following ordered approach is proposed: 1. Vital signs (including supine and standing blood pressure measurement) 2. Anthropometric measurements (plotted on percentile charts) 3. General examination (skin, skull, spine, dysmorphism and meningeal signs) 4. Mental status examination (mini-mental status examination) 5. Cranial nerves (I to XII) 6. Motor system (inspection, palpation, and percussion) 7. Cerebellar examination (including gait) 8. Sensory system (peripheral and cortical sensations).

Vital signs. Examination of the nervous system is never complete without taking the vital signs. High temperature or hypothermia, particularly in infants, may indicate an underlying CNS infection. Temperature instability could be a sign of brain stem dysfunction. Blood pressure should be measured in the supine and standing positions to assess postural drop as in patients with vaso-vagal syncope. In patients with disturbed level of consciousness or seizures, high blood pressure and bradycardia (Cushing reflex) indicate increased intracranial pressure (e.g. due to hemorhage or a space occupying lesion). The respiratory pattern may also indicate CNS dysfunction.[7] Cheyne-Stokes breathing (periodic breathing pattern in which phases of hyperpnea regularly alternate with apnea) usually indicates bihemispheric dysfunction. Central hyperventilation (sustained, rapid, and deep hyperpnea) is produced by lesions in the lower midbrain or upper pons. Apneustic breathing (prolonged pause at full inspiration) may occur after damage to the mid or lower pons. Cluster breathing (disordered sequence of breaths with irregular pauses) may result from damage to the lower pons or upper medulla. Finally, ataxic breathing (completely irregular pattern of breathing with random deep and shallow breaths) is usually due to a lesion in the central medulla.[7]

Anthropometric measurements. Weight, height, and head circumference should be measured and plotted on age appropriate percentile charts. The distinction between large head (macrocephaly) and large brain (megalencephaly) is important. If megalencephaly is suspected the parentís head circumferences should also be measured as benign autosomal dominant megalencephaly is one of the commonest causes. Short and tall stature, as well as, under or overweight may be associated with certain disorders and syndromes that may have neurological features or complications.[8,9] A summary of these disorders is shown in Table 1.

General examinations. There are certain aspects of the general (non-neurological) examination that are of relevance to the nervous system including examination of the skin, skull, spine, and assessment for dysmorphic features and meningeal irritation signs. Skin exam is important as the skin and the nervous system have the same embryologic origin (ectoderm). Therefore, developmental CNS disorders may have associated skin signs (neurocutaneous syndromes). Table 2 shows a summary of the cutaneous features of some of these disorders.[10] Examination of the skull for shape, fontanel size and tenseness, sutures for premature fusion or wide separation, and sinus tenderness are important.[11] As well, skull auscultation for bruits may indicate an underlying arteriovenous malformation.[11] For this purpose, the bell of the stethoscope should be placed over the fontanels, eyes, and sides of the head. Examination of the spine for deformities (scoliosis, lordosis, gibbus) or midline lesions (defect, hair tuft, or lipoma) may indicate an underlying spinal dysraphism. Many syndromes may have associated CNS anomalies or features. It is important therefore to carefully assess the patient for dysmorphic features (face, mouth, palate, hands and feet). Finally examination for meningeal irritation signs is important. Neck stiffness may indicate meningitis, meningoencephalitis, subarachnoid hemorrhage, or cerebellar herniation.

Mental status examination. Detailed assessment may be difficult in young children, however, the mini mental status examination can be done in older children and adults as shown in Table 3.[3,12] This is a screening test that includes a series of questions and commands to assess various higher cortical functions including orientation, registration, attention, calculation, recall, and language. Cognitive impairment is considered if the total score is less than 23. It is important to stress that this is only a screening test and more detailed assessments are needed if it was abnormal. The test may also miss subtle or selective cognitive impairment, particularly in executive functions.

Cranial nerve assessment[6]. Olfactory Nerve (I). To test smell, each nostril should be examined separately (by blocking the other nostril). The examiner should use familiar odors (e.g. mint, vanilla, or coffee). Avoid irritant smell, which will

Table 1 - Examples of the CNS features of some disorders and syndromes associated with abnormal stature or abnormal body weight.

Abnormality	Syndromes or disease states	CNS features
Short stature	Hypothyroidism	Mental retardation
	Turner's syndrome	Hearing loss
	Cockayne syndrome	Peripheral neuropathy
	De Lang syndrome	Microbrachycephaly
Tall stature	Fragile X syndrome	Mental retardation
	Sotos syndrome	Macrocephaly
	Weaver syndrome	Progressive spasticity
	Marfan syndrome	Risk of embolic stroke
Low body weight	Congenital Rubella syndrome	Mental retardation, deafness
	Seckel syndrome	Microcephaly
	Rubinstein Taybi syndrome	EEG abnormalities
	Fetal Hydantoin syndrome	Mental retardation, strabismus
Overweight	Beckwith Weidemann syndrome	Large fontanels
	Bardet Biedl syndrome	Retinitis pigmentosa
	Prader Willi syndrome	Hypotonia

Table 2 - Examples of the cutaneous features of common neurocutaneous syndromes.

Neurocutaneous syndrome	Inheritance	Skin manifestations
Neurofibromatosis Type 1	Autosomal dominant	Cafe-au-lait spots
		Neurofibromas
		Axillary or inguinal freckling
Tuberous Sclerosis	Autosomal dominant	Adenoma sebaceum
		Ash-leaf spots
		Fibrous plaques
		Shagreen patches
		Periungual fibroma
Sturge Weber syndrome	Sporadic	Facial angioma (port-wine stain)
Ataxia Telangiectasia	Autosomal recessive	Telangiectasias (eyes, eyelids, ears, cubital, and popliteal fossa)
Linear Naevus syndrome	Sporadic	Sebaceous naevus
		Verrucous naevus
		Acanthosis nigricans

Table 3 - The mini-mental status examination (total score = 30*).

Examination Item	Score
Orientation to time, date, day, month, and year	1 point each
Orientation to place (ward, hospital, district, city, country)	1 point each
Registration (name 3 objects and ask the patient to repeat)	1 point each
Attention and calculation (subtract 7s from 100)	5 points
Recall (repeat the 3 objects named in registration)	1 point each
Language	
Name 2 objects (e.g. pen and watch)	1 point each
Repeat a sentence	1 point
3 step verbal command	1 point each
1 step written command	1 point
Write a sentence	1 point
Drawing intersecting pentagons	1 point

* = the patient is considered cognitively impaired if the total score is les than 23.

Table 4 - Localization of some important deep tendon reflexes*.

Deep tendon reflex	Muscle involved	Nerve supply	Root supply
Biceps	Biceps	Musculocutaneous	C5, C6
Triceps	Triceps	Radial	C6, C7, C8
Pectoralis	Pectoralis Major	Pectoral	C6, C7, C8
Brachioradialis	Brachioradialis	Radial	C5, C6
Finger flexors	Flexor Digitorum	Median and Ulnar	C7, C8, T1
Knee	Quadriceps Femoris	Femoral	L2, L3, L4
Adductor	Adductors	Obturator	L2, L3, L4
Ankle	Soleus/ Gastrocneumius	Sciatic/Tibial	S1, S2
Plantar	Small foot muscles	Plantar	

* = Considered present (+1), normal (+2), brisk (+3), pathological (+4).

stimulate the fifth cranial nerve (responsible for withdrawal). Upper respiratory tract infections are the commonest cause of hyposmia (reduced smell) or anosmia (complete less of smell). Other causes include frontal brain tumor or skull fractures involving the cribriform plate.

Optic Nerve (II): Five modalities should be examined (visual acuity, fields, pupillary reflex, fundi, and color vision). Snellen chart should be used for visual acuity testing. The patient should read the chart from a distance of 20 feet (6 meters), alternately covering one eye, then the other.[6] Pocket-size charts held at 14 inches from the patientís eyes can be used if wall charts are not available. If the patient wears glasses, he should be tested while he is wearing them. The test should be conducted with adequate illumination. If the patient cannot read the largest letter, finger counting and hand motion detection should be performed. Visual field testing is commonly assessed using the confrontation test, which is a crude screening method to detect major visual field defects. Another technique involves finger counting in all 4 field quadrants with one eye covered. Presenting two simultaneous visual stimuli could detect homonomous visual neglect. Direct and consensual pupillary reflex should be tested after dimming the room light. Remember that the afferent limb is 2nd and efferent is 3rd cranial nerve. Marcus gun pupil (afferent pupillary defect) results from a lesion in the optic nerve. This will result in slow pupillary dilatation (rather than quick constriction) on the affected side when the consensual reflex is tested. Finally fundal examination is important to examine the optic disc, vessels, and macula.

Occulomotor, trochlear, and abducent nerves (III, IV and VI): Inspect the eyelids for ptosis (III). Test eye movements (smooth pursuit and saccades) by asking the patient to follow an object (e.g. fingertip) moving in the horizontal, vertical and oblique planes. Remember that the rectus muscles move the eyes in the direction of their names (e.g. the medial rectus moves the eye medially). The oblique muscles move the eyes in the opposite direction (e.g. the superior oblique moves the eye inferiorly). As well, the superior oblique muscle moves the eye inward and the inferior oblique muscle moves the eye outward in a rotatory movement. Test accommodation by bringing an object slowly closer to the fixating eyes looking for convergence and miosis.

Trigeminal Nerve (V): As discussed under the sensory examination, pain and touch sensation should be examined in the V1, V2 and V3 bilaterally. Testing for the corneal reflex, particularly in patients with disturbed level of consciousness will examine two cranial nerves, afferent (VI) and efferent (VII). Teeth clenching is used to examine the masseters and temporalis muscles and lateral jaw movements for pterygoids. Jaw reflex (5th nerve constitutes both afferent and afferent limbs) is exaggerated in patients with frontal lobe dysfunction (release reflex), or in extrapyramidal disorders (e.g. Parkinson's disease).

Facial Nerve (VII): Examination of the muscles of facial expressions includes mainly the frontalis, nasalis, orbicularis oculi and oris muscles. Remember that an upper motor neuron lesion will spare the frontalis and orbicularis oculi muscles because of bilateral corticobulbar innervations while a lower motor neuron lesion will involve both upper and lower halves. As well, examine taste on the anterior 2/3 of the tongue using cotton swabs soaked with salted or sweetened water applied to the tongue's lateral sides. During this test, each half should be tested separately with the tongue held out of the mouth to avoid stimulating other taste receptors in the oropharynx.

Vestibulococclear Nerve (VIII): Assessment of balance and hearing, which may require the use of a bell, soft voice, or a tuning fork. A simple hearing test involves rubbing the index and thumb fingers together close to each ear. Rinne and Weber tests are performed using a 512Hz tuning fork. Description of these tests is beyond the scope of this review and the interested reader can consult other references.[3,6]

Glossopharyngeal and Vagus Nerves (IX, X): Examine the gag reflex (afferent IX and efferent X) by touching the posterior pharynx using a tongue depressor. Examine the soft palate movements (watching the uvula while saying "Ahh"). In unilateral palatal weakness, remember that the uvula will deviate towards the normal side during palatal movements.

Spinal Accessory Nerve (XI): Shoulder drop or asymmetry may appear on the side of trapezius muscle weakness. Shrugging the shoulders will reveal ipsilateral weakness. Examine the sternocleidomastoid muscle by asking the patient to turn the head laterally against resistance. Note that the left muscle will turn the head to the right.

Hypoglossal Nerve (XII): The tongue should be inspected for bulk and fasiculations, which may be detected only in the tongue particularly in children. This is true because of the absence of subcutaneous fat. Protruding the tongue and pushing against the examiner's finger through the cheeks will examine normal movements and power. Unilateral paralysis will result in tongue deviation towards the weak side.

Motor system. Gait assessment includes observing the patient walk normally and run. Beginning sometime between 4 to 6 years of age, most normal children will participate in a screening motor examination.[13] Before that age, the examination should be informal and depends heavily on observation according to the child's acquired motor skills.[13] The examiner should observe the arms for swinging and the feet for heel strike (the heel normally strikes the floor before the forefoot).

Table 5 - Differentiating features of upper and lower motor neuron lesions.

Feature	Upper Motor Neuron Lesion	Lower Motor Neuron Lesion
Site of the lesion	Cerebral hemispheres, cerebellum, brainstem, spinal cord	Anterior horn cell, nerve roots, peripheral nerves, neuromuscular junction, muscles
Muscle weakness	Quadriplegia, hemiplegia, diplegia, paraplegia	Proximal (myopathy) Distal (neuropathy)
Muscle tone	Spasticity, rigidity	Hypotonia
Fasiculations	Absent	Present (particularly tongue)
Tendon reflexes	Hyperreflexia	Hypo/areflexia
Abdominal reflexes	Absent (depending on the involved spinal level)	Present
Sensory loss	Cortical sensations	Peripheral sensations
Electromyography (EMG)	Normal nerve conduction Decreased interference pattern and firing rate	Abnormal nerve conduction Large motor units Fasciculations and fibrillations

Table 6 - Important normal developmental reflexes.

Developmental reflex	Age of development	Age of disappearance
Truncal incurvation	Birth	1-2 months
Rooting	Birth	3 months
Moro	Birth	5-6 months
Tonic neck	Birth	5-6 months
Palmar grasp	Birth	6 months
Adductor spread	Birth	7-8 months
Plantar grasp	Birth	9-10 months
Landau	5-10 months	24 months
Parachute	8-9 months	Persist

Functional power assessment will include tiptoe and heel walk, hopping on one foot, and Gower's sign. Gower's sign is the inability to rise from a sitting position without holding an object for support including the patient's own body. A positive sign suggests proximal lower limb muscle weakness.

Inspection of various muscle groups for (bulk, atrophy, fasiculations, chorea, tremor, myoclonus), or maintained posturing or deformity is important followed by palpation for muscle firmness, tenderness, tone or palpable nerves. Assessment of power is also important and a specific grading system should be followed.[14] It includes 6 categories with (0) meaning no contraction, (1) contraction with minimal movement, (2) movement with gravity, (3) movement against gravity, (4) movement against some resistance, and (5) meaning movement against full resistance (normal power). Grade 4 is best subdivided into 4-, 4, 4+, indicating slight, moderate and strong resistance respectively.[15] Recognizing subtle limb weakness is fundamental to the motor examination as it may be the first sign of an upper motor neuron lesion.[16]

Deep tendon reflexes are critical in localizing the site of lesion as shown in Table 4. As well, they are important for differentiating upper versus lower motor neuron lesion weakness as shown in Table 5. Exaggerated reflexes are considered pathological (+4) if associated with spasticity, clonus, or reflex spread (e.g. hip adduction on tapping the knee jerk or finger flexion on tapping the biceps). It is important to note that preterm infants, particularly those less than 33 weeks of gestation, have decreased elicitation rates for patellar and biceps reflexes and have decreased overall reflex intensity when compared with their older counter parts.[17]

Developmental reflexes are important reflexes that can be elicited in young infants.[18] Table 6 shows a summary of these reflexes with normal ages of appearance and disappearance. They are abnormal when absent or weak (diffuse brain insults or drug effects). However, the reflexes that appears at birth are vigorous and complete only at term and may be weak or absent in the preterm (<37 weeks gestation) infant.[17] If these reflexes persist or become exaggerated they may indicate upper neuron lesion. As well, asymmetry may be abnormal. For example, asymmetric moro reflex may indicate hemiplegia, brachial plexus injury, shoulder dislocation, or fractured humerous or clavicle.

Cerebellar examination[3]. Examination of coordination starts by examining the gait. In cerebellar disease, the patient is off balance with eyes open and worse with eye closure (see later under sensory examination). Walking on a straight line will identify unilatereal hemispheric cerebellar disease as the patient will sway towards the affected side. Tandem walk (walking on a straight line with feet closely attached and alternating in front of each other) is more difficult to perform and may identify subtle cerebellar ataxia. Finger nose or heel shin test, rapid alternate hand movements of foot tap will test for limb ataxia. Note that the arms have to be

adequately stretched during the finger nose test to identify intention tremor as the amplitude of this tremor increases as it reaches the target.

Sensory system. There are three main sensory modalities to be examined: 1. Special sensations (discussed under cranial nerves), 2. General sensations (light touch, superficial pain, temperature, vibration and proprioception), 3. Cortical sensations (graphesthesia, stereognosis, neglect and 2 point discrimination). Abnormalities of general sensations result from lesions in the lower motor neuron. Light touch should be tested using a napkin tip or a twisted tip of cotton wool, working from the insensitive toward the sensitive area.[19] In the case of a hypersensitive area, the direction of testing should be reversed to minimize discomfort. One of the common pitfalls is to rapidly move the tip of the cotton in a linear or circular manner. This results in a stronger tickling sensation and detection of motion by cutaneous hair. Therefore milder degrees of sensory loss can be missed. In general both sides of the body and corresponding limbs should always be checked in an alternating fashion for comparison.

Regarding pain sensation a disposable pin should be used (e.g. safety pin). The use of needles should be discouraged as they are designed to penetrate the skin and therefore may result in injury. The same rule of applying the stimuli from the analgesic area and working outwards should be followed. The area of sensory defect should be outlined by a series of dots with the patient's eyes closed. Use irregular stimulus timing so the patient does not know when to expect the next touch or pinprick.[19] If the sensory defect is hysterical, inconsistencies in the marking will be revealed easily. Other sensations include temperature, which can be checked using test tubes full of warm and cold water. In practice, the metal part of the patellar hammer or stethoscope is usually cold and can be used as a screening test. For vibration sense a 128 Hz tuning fork should be applied over the distal bony prominences followed by more proximal testing with eyes closed. The examiner should teach the patient what to expect before performing the test as some may report the pressure rather than vibration sensation. Romberg sign will help in testing position sense as the patient stands with outstretched hands and closely placed feet. Off balance with eye closure represents a positive sign, indicating sensory ataxia.

Regarding abnormal cortical sensations, they result from an upper motor neuron lesion usually involving the right parietal lobe. Abnormal cortical sensations include agraphesthesia (inability to identify written numbers or letters on the patient's skin e.g. palms), astereognosis (inability to identify an object placed in the patient's hand e.g. key), neglect (inability to identify one of two simultaneous stimulation points), and 2 point discrimination (particularly on the finger tips), all performed with eye closure.

In summary, we presented a concise and simple outline for the examination of the nervous system. Different techniques of eliciting physical signs and possible pitfalls in the examination were discussed. Although many students and residents will continue to consider examining the nervous system as one of the most difficult parts of the physical examination, we hope that in this review certain problems such as organizing a complete exam, eliciting and interpreting neurological signs were highlighted and clarified. Repeated examinations, preferably in conjunction with another colleague for instructive criticism, will remain the key for successfully and consistently eliciting the various neurological signs.

Acknowledgments: To all physicians and surgeons who worked with us at King Abdulaziz University Hospital and King Khalid National Guard Hospital (Jeddah, Kingdom of Saudi Arabia), IWK-Grace Health Center and Queen Elizabeth II Health Sciences Center, Dalhousie University (Halifax, Nova Scotia, Canada) and Ottawa Civic Hospital, University of Ottawa (Ottawa, Ontario, Canada).

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