ORTHOPAEDIC NEUROLOGY

A Diagnostic Guide to Neurologic Levels

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Associate Clinical Professor of Orthopaedic Surgery and Director of Scoliosis Service, Albert Einstein College of Medicine; Deputy Director of Orthopaedic Surgery and Attending Physician, Bronx Municipal Hospital Center; Associate Attending, Hospital for Joint Diseases
New York, New York

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Richard Hutton

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Preface

Years ago I felt the need for a manual that would reduce the diagnosis of neurologic levels to its common denominators, and combine them with the basic principles of neurology to assist in the appraisal of spinal cord and nerve root problems. As the book began to take shape in my mind, it became apparent that the most important aspects of transmitting this information would lie in its organization and the clarity of illustrations. The final structure would have to be simple and clear, containing the material essential to teach the crucial concepts of examination and diagnosis.

This book has been written for those who wish to understand more clearly the *clinical* concepts behind neurologic levels. It has been designed to be read sequentially, from cover to cover. Each chapter presents basic neurologic information first, then gives it clinical significance by applying it to the diagnosis of the more common neurologic pathologies. The pattern of teaching thus moves from concept to practice, and from the general rule to its specific application.

However, clinical experience remains the key to real understanding. A book can do no more than present, clearly and concisely, suggested methods of evaluation. In the interest of such clarity, some of the information presented here has been simplified. The clinical findings for each neurologic level have, for example, been stylized to make basic concepts and facts easier to understand; it must be clinical experience that uncovers the variations and exceptions which arise in individual patients. For as Goethe said, "What one knows, one sees."

This book is an expression of my teaching experience at the Albert Einstein College of Medicine, where I have watched orthopaedic, neurosurgical, neurologic, physical medicine, and family practice residents, as well as physical therapists, seek this knowledge. I hope this information, and the special way in which it is organized, provide the understanding necessary to assess the involvement of neurologic levels.

STANLEY HOPPENFELD, M.D.

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Contents

Introduction

The spinal cord is divided into segments. Nerve roots exit the spinal cord at each segmental level, and are numbered in relation to the level from which they exit. There are eight cervical, twelve thoracic, five lumbar, and five sacral nerves. The C5-T1 segments innervate the upper extremity, and the T12-S4 segments the lower extremity; these two sections of the cord have the greatest clinical significance.

Pathology affecting the spinal cord and nerve roots commonly produces symptoms and signs in the extremities according to the specific neurologic levels involved. These levels can usually be diagnosed clinically, since each level of injury has its own characteristic pattern of denervation.

The common denominator in injuries to either the cord or the nerve root lies in the segmental pattern of alteration of motor power, sensation, and reflex in the extremities. Evaluation of the integrity of the neurologic levels depends upon a knowledge of the *dermatomes*, *myotomes*, and *reflexes*. Different dermatomes (areas of sensation on the skin supplied by a single spinal segment) and myotomes (groups of muscles innervated by a single spinal segment) are affected depending upon the level involved and upon whether the pathology involves the cord or the nerve roots emanating from it. It is through a clinical evaluation of motor power, sensation, and reflex that the correct neurologic level of involvement can be established.

MOTOR POWER

The impulses that supply motor power are transported in the spinal cord via the long tracts, and in particular via the corticospinal tracts. Interruption of the nerve root causes denervation and paralysis of its myotome; interruption of the tract causes spastic paralysis (Fig. I–1). Pressure on the nerve root may produce a decrease in muscle strength that can be evaluated best through the standards set by the National Foundation of Infantile Paralysis, Inc., Committee on After-Effects, and adopted by the American and British Academies of Orthopaedic Surgeons (Table I–1).

In learning to grade a muscle, it is best to remember that a grade 3 muscle can move the joint through a range of motion against gravity. Above grade 3 (grades 4 and 5), resistance is added to the muscle test; below grade 3 (grades 2, 1, and 0), gravity is eliminated as a factor.

Muscle testing should be repeated on a regular basis to determine whether the level of the lesion has changed and created either further muscular paralysis or improvement. Repetitive muscle testing against resistance helps determine whether the muscle fatigues easily, implying weakness and neurologic involvement.

SENSATION

Sensation of pain and temperature is carried in the spinal cord via the lateral spinothalamic

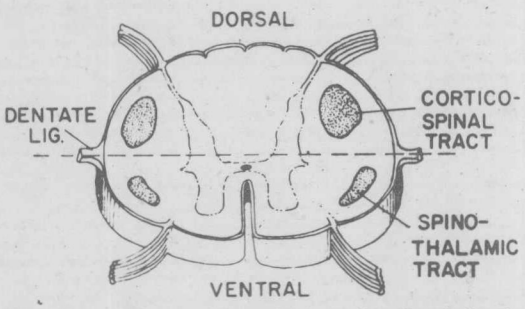

FIG. I–1. The corticospinal and spinothalamic tracts.

tract, whereas touch is carried in the ventral spinothalamic tract (Fig. I–1). Pathology to the cord or nerve root results in the loss of light touch, followed by loss of sensation of pain. During a recovery from nerve root injury, sensation of pain returns before light touch. The two sensations are tested separately, light touch with a cotton swab, pain with pinpricks.

When testing for pain, use a pin in a gentle sticking motion. The pinpricks should follow in succession, but not too rapidly. A pinwheel is an excellent alternative method of evaluating alterations in sensation, since two neurologic pinwheels can be used simultaneously, one on each side, to permit bilateral comparison. Safety pins may also be used. The use of needles is not recommended since they have cutting surfaces and may injure the patient. Once an area of altered sensation is found, it can be located more precisely by repeated testing from the area of diminished sensation to the area of normal sensation. Sensation tests depend largely upon subjective responses; full cooperation of the patient is necessary.

After sensation is evaluated, the results should be recorded on a dermatome diagram as normal, hyperesthetic (increased), hypesthetic (decreased), dysesthetic (altered), or anesthetic (absent).

REFLEX

The stretch reflex arc is composed of an organ capable of responding to stretch (muscle spindle), a peripheral nerve (axon), the spinal cord synapse, and muscle fibers (Fig. I–2).

TABLE I–1. MUSCLE GRADING CHART

Muscle Gradations	*Description*
5—Normal	Complete range of motion against gravity with full resistance
4—Good	Complete range of motion against gravity with some resistance
3—Fair	Complete range of motion against gravity
2—Poor	Complete range of motion with gravity eliminated
1—Trace	Evidence of slight contractility. No joint motion
0—Zero	No evidence of contractility

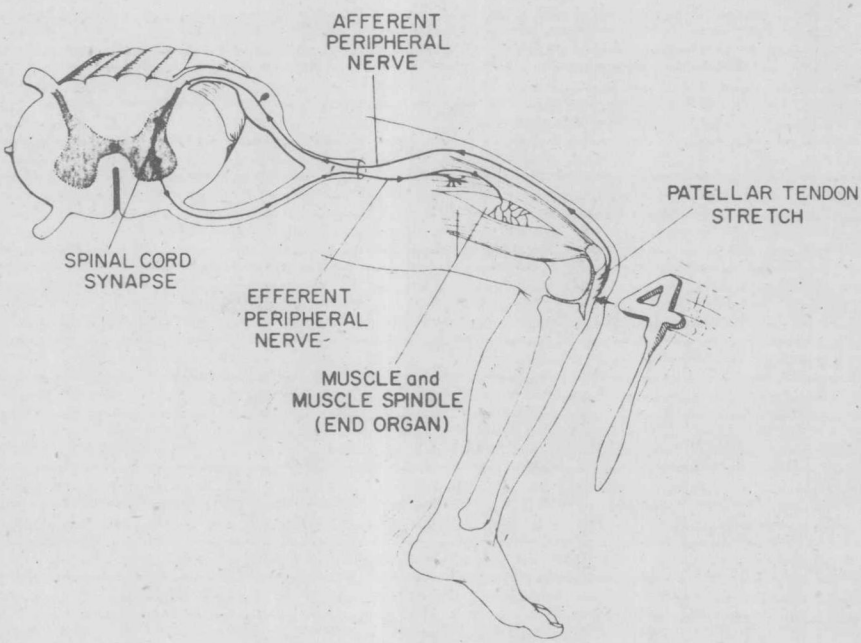

FIG. 1–2. The stretch reflex arc.

Impulses descend from the brain along long (upper motor neuron) tracts to modulate the reflex. As a general rule, an interruption in the basic reflex arc results in the loss of reflex, while pressures on the nerve root itself may decrease its intensity (hyporeflexia). Interruption of the upper motor neuron's regulatory control over the reflex will ultimately cause it to become hyperactive (hyperreflexia).

Reflexes should be reported as normal, increased, or decreased, an evaluation which requires that one side be compared with the other. Bilateral comparison provides a direct, immediately accessible way to detect any alteration in reflexes and is essential for an accurate diagnosis of pathology since the degree of reflex activity varies from person to person.

The concept of determining neurologic levels applies to the evaluation of spinal injuries, developmental anomalies, herniated discs, osteoarthritis, and pathologic processes of the cord itself. All these pathologic processes result in specific segmental distribution of neurologic signs in the extremities because of their direct effect on the spinal cord and nerve roots.

Note that the difference in findings between cord or nerve root pathology as opposed to peripheral nerve injuries is reflected in differences in the distribution of the neurologic findings of motor power, sensation, and reflex. While each dermatome and myotome is innervated at a cord level and by a peripheral nerve, each has its own distinct pattern of innervation.

Part One

Nerve Root Lesions by Neurologic Level

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1 Evaluation of Nerve Root Lesions Involving the Upper Extremity

Examination by neurologic level is based upon the fact that the effects of pathology in the cervical spine are frequently manifested in the upper extremity (Fig. 1–1). Problems which affect the spinal cord itself or nerve roots emanating from the cord may surface in the extremity as muscle weakness or abnormality, sensory diminution, and abnormality of reflex; the distribution of neurologic findings depends upon the level involved. Thus, a thorough neurologic testing of the extremity helps determine any involvement of neurologic levels; it may also assist in the evaluation of an assortment of problems originating in the cervical cord or its nerve roots.

The following diagnostic tests demonstrate the relationship between neurologic problems in the upper extremity and pathology involving the cervical nerve roots. For each neurologic level of the cervical spine, motor power, reflexes, and areas of sensation in the upper extremity should be tested so that the level involved can be identified. We have begun individual nerve root testing with C5, the first contribution to the clinically important brachial plexus. Although C1-C4 are not included in our tests because of the difficulty of testing them, it is crucial to remember that the C4 segment is the major innervation to the diaphragm (via the phrenic nerve).

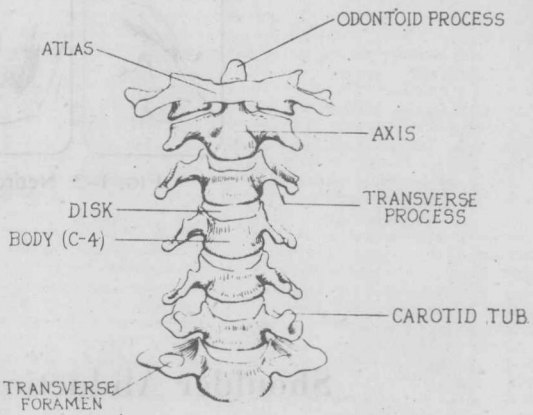

FIG. 1–1. The cervical spine.

TESTING OF INDIVIDUAL NERVE ROOTS: C5 TO T1

Neurologic Level C5

Muscle Testing. The deltoid and the biceps are the two most easily tested muscles with C5 innervation. The deltoid is almost a pure C5 muscle; the biceps is innervated by both C5 and C6, and evaluation of its C5 innervation may be slightly blurred by this overlap.

DELTOID: C5 (AXILLARY NERVE). The deltoid is actually a three-part muscle. The anterior deltoid flexes, the middle deltoid abducts, and the posterior deltoid extends the shoulder;

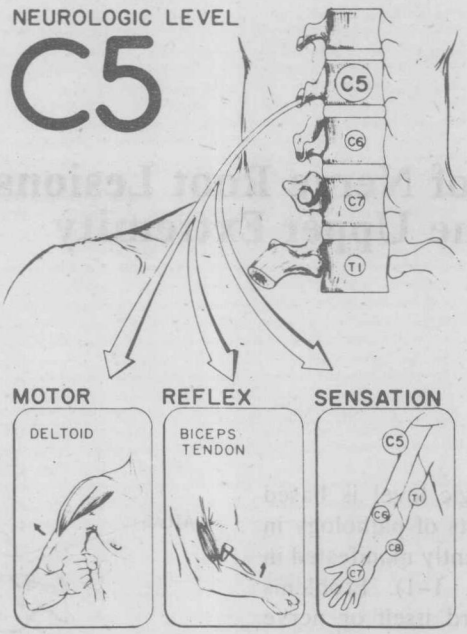

FIG. 1–2. Neurologic level C5.

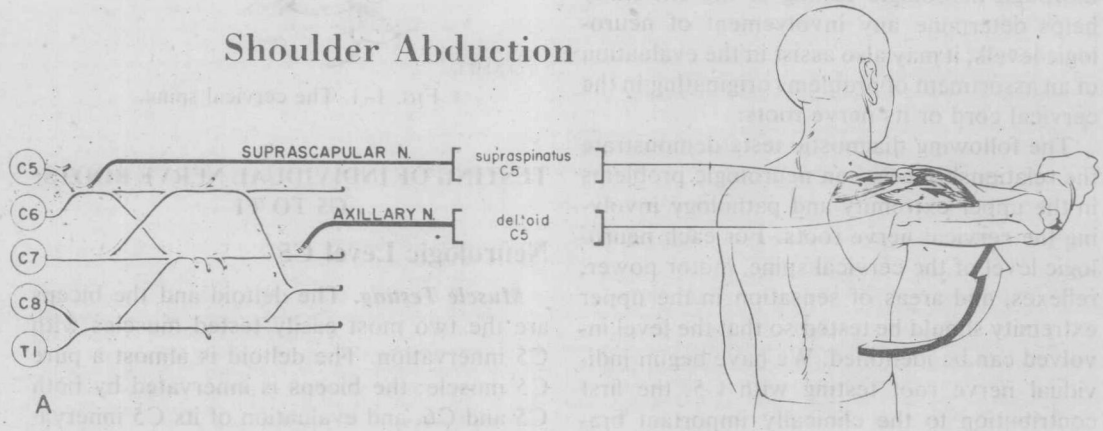

FIG. 1–3A.

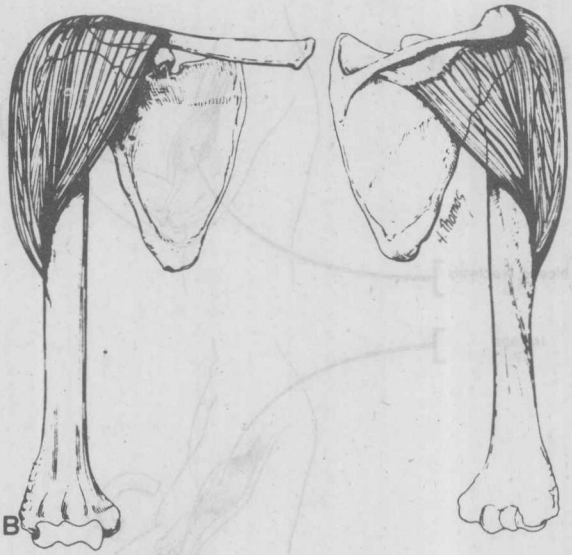

FIG. 1–3B. *Deltoid.*
Origin: Lateral third of clavicle, upper surface of acromion, spine of scapula.
Insertion: Deltoid tuberosity of humerus.

FIG. 1–3C. *Supraspinatus.*
Origin: Supraspinous fossa of scapula.
Insertion: Superior facet of greater tuberosity of humerus, capsule of shoulder joint.

FIG. 1–4. Muscle test for shoulder abduction.

of the three motions, the deltoid acts most powerfully in abduction. Since the deltoid does not work alone in any motion, it may be difficult to isolate it for evaluation. Therefore, note its relative strength in abduction, its strongest plane of motion (Fig. 1–2).

Primary shoulder abductors (Fig. 1–3).
1. Deltoid (middle portion)
   C5, C6 (Axillary nerve)
2. Supraspinatus
   C5, C6 (Suprascapular nerve)

Secondary shoulder abductors
1. Deltoid (anterior and posterior portions)
2. Serratus anterior (by direct stabilizing action on the scapula, since abduction of the shoulder requires a stable scapula).

Stand behind the patient and stabilize the acromion. Slide your stabilizing hand slightly laterally so that, while you stabilize the shoul-