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MEDICO-LEGAL ASPECTS OF THE NERVOUS SYSTEM AS A FUNCTIONING UNIT OF THE BODY

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We have had the pleasure of working together in recent years on Law-Science problems. During that time we have become increasingly convinced that it is necessary for trial lawyer and scientist alike to think of the human being in terms of the nine main organ systems,[1] reserving a tenth category for the field of personality[2] as the latter represents a synthesis of component structures and functions into variable reaction and behavior patterns. An injury or disability may involve impairment or destruction of an anatomic member or of physiological function; it may involve effects on personality, or psychic values, alone, without discoverable organic lesion,[3] or it may cause dis-

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1. These are the integumentary system (the skin); the skeletal system; the muscular system; the respiratory system; the digestive system; the cardiovascular system; the uro-genital system; the endocrine system and the nervous system. In the Law-Science Short Courses on "Legal Medicine and Elements of Medico-legal Litigation," conducted four times a year for trial lawyers, consideration is given to the structure, function and diseases of each organ system. Stress is also placed upon the criteria of proof which should be met to establish possible and probable causal connection between various types of traumatic stimuli and disabilities allegedly produced thereby.

2. This field involves psychiatry but also every other specialty which attempts to relate total function to specific causes; thus, it includes every known medical specialty, anatomy and physiology and other basic medical sciences, psychology, psychosomatic medicine and even sociology. It includes every dimension of personality and behavior ranging from study of the child (pediatrics) to study of the aged (geriatrics).

3. As, for instance, traumatic neurosis (and rarely, traumatic psychosis) precipitated by adequate physical or psychic trauma. See: Smith and Solomon, *Traumatic Neuroses in Court,* 30 VA. L. REV. 87 (1943); Smith, *Relation of Emotions to Injury and Disease: Legal Liability for Psychic Stimuli,* 30 VA. L. REV. 193 (1944); Smith, *Psychic Interest in Continuation of One's Own Life: Legal Recognition and Protection,* 98 U. OF PA. L. REV. 781 (1950).

locations both in organ systems and in over-all personality.[4] To achieve a scientific approach to medico-legal problems one must undertake focal analysis in the discovery, or exploratory phases, and synthesis in the phases of evaluation and prognosis.[5] By common agreement, the nervous system is the most highly evolved, influential and sensitive system in the body, acting as a master control for reception and interpretation of sensation and for initiation of motor activity. The trial lawyer needs to understand the nervous system because psychiatric and organic neurological disabilities are complex. The interpretation of such disabilities may lead to the award of or failure to award large sums of money when litigation occurs. It becomes of very material importance to know whether the symptoms are of psychological origin and are thus likely to be temporary, or whether they are of organic origin (arising from injury or destruction of nerve cells) with the increased likelihood that some effects, at least, may be permanent.

But though the nervous system is more complex in its organization and function than are other units of the body, and much remains to be learned about it, even now one can readily understand a great deal about organic neurological disturbances[6] by having a firm grasp upon a relatively few fundamental anatomical and physiological facts. The intricacies of nerve function will interest research workers forever. Fortunately it is not necessary to know about these frontiers of knowledge in order to understand the well established principles of neurology.[7]

The neurological examination is simply an assessment of the nervous system as a functioning unit. The close alliance between neurology and psychiatry tended in the past to shroud neurology in mysticism. The rapid development of neurological surgery has improved neurology in one definite respect. Formerly, the neuropsychiatrist interpreted his findings as indicating, we will say, a tumor in a particular

4. Most organic lesions which involve dysfunction or disability or losses or impairments perceptible to the victim will evoke personality responses; these may be reparative, indifferent or destructive, in various degrees, depending upon complex determinants including the pre-traumatic personality structure of the victim and adequacy of treatment.

5. To illustrate: a person with serious organic injuries may be able to minimize or overcome disabilities through courage coupled with indicated rehabilitation measures; a person with slight injuries may become totally disabled if his pre-traumatic personality was already highly neurotic or disorganized so that the stimulus served as a trigger mechanism to evoke a psychological collapse already imminent. Prognosis, or future outlook, often depends on the quality of the victim's personality structure and motivations. Much less success is to be expected in rehabilitation of poorly motivated persons than is usually accomplished with well motivated individuals.

6. *Organic neurological disturbances:* Changes in physiology or functioning of nerve tissue due to damage or destruction of nerve cells or tracts.

7. *Neurology:* The science of the nervous system; that medical specialty which has to do with study of nerve function and diagnosis and treatment of disease of the nervous system, in the latter connection aided by the neurosurgeon who is likewise trained in neurology.

part of the nervous system, but no immediate confirmation or denial was possible. Now, with surgical verification or denial, neurological diagnosis must accurately predict the findings. It is this cold, calculating style of neurology, unhampered by mysticism and philosophy, that we hope to explain. The neurological examination, carefully and *critically* made, is the basis of interpretation. Unfortunately, the personal equation enters more frequently into the examination than into any other phase of neurology. With the *hypothesis* a *variable,* it is apparent that we are not dealing with geometric precision.

Although neurology is an important subject in all medical teaching, we find many doctors whose interest in the nervous system is so slight that their opinions on neurological subjects are hardly more enlightened than those of intelligent laymen.[8] For this reason statements by physicians not truly qualified in neurology must often be discounted. Unfortunately the opinion of a physician often becomes valueless in medico-legal matters because of bias or partisanship. A professional opinion tempered or altered by personal considerations is of little help in making a diagnosis.

The fundamental structure and function of the nervous system must be presented before describing how damage to it can be assessed by means of the neurological examination.

Form and Function of the Nervous System

The nervous system is so poorly understood in general that its definite anatomical formation is considered by many as being too subtle

8. Great injury to the science of proof can result from the current tendency of courts to permit any holder of an M.D. degree to testify on specialty subjects actually foreign to his training or experience. *Cf.* 2 WIGMORE, EVIDENCE § 569 (3d ed. 1940); 11 R.C.L., *Expert and Opinion Evidence* § 27 (1916). The limiting defect of the Minnesota plan for auditing or policing medical testimony is the tacit, but specious, assumption that all doctors know the facts and are guilty of imposition or fraud if they withhold or distort them. Actually, ignorance is a greater foe of trustworthy medical evidence, than is fraud or connivance. Fortunately, however, there is a perceptible swing, among American jurisdictions, to the minority view that a physician or surgeon must qualify as an expert before he is competent to testify on medical specialities, at least in cases where he has not been attending physician. See Note, 54 A.L.R. 860, 866 (1928) (citing decisions from Alabama, Maine and Mississippi).

To qualify to take the examinations for certification by the Specialty Board in Neurology or Psychiatry, the candidate must have completed three years post-graduate study in an approved institution with two additional years of study or hospital experience. To become eligible for the examinations in both neurology and psychiatry, the candidate must have completed five years post-graduate study, plus two additional years of study or hospital experience.

Attention is drawn to recent authority that the *voir dire* ruling of the trial judge, in passing upon competency of expert witnesses, is provisional only. In Carbonneau v. Lachance, 307 Mass. 153, 29 N.E.2d 696 (1940), the Supreme Judicial Court of Massachusetts held that the trial court has a duty to maintain surveillance of expert testimony throughout the trial. In his sound discretion, the judge may reverse his preliminary ruling, substitute a finding that the supposed expert is not qualified, dismiss him as a witness and order his completed testimony cancelled, should it appear during the course of trial that he is not actually competent to provide expert illumination of the issues before the court.

to have substance. The human brain weighs about three pounds and has much the same consistency as the pig or calf brain. It is sufficiently durable to tolerate exposure to the air for several hours at operation. The spinal cord is about the size of the little finger, is firmer than brain substance, and is the sole connection between brain and body with the chief exception of the vagus nerves[9] which originate within the skull and supply important organs contained within the chest and abdomen. The nerves that arise by rootlets from the spinal cord are strong, firm bundles when they emerge from the vertebral canal (the bony structure housing the spinal cord). The largest and longest nerve, the sciatic nerve,[10] is approximately the size of the spinal cord. The branches become smaller as repeated division occurs, but can be seen without magnification until just prior to their terminations. In addition to the central nervous system and the cranial[11] and peripheral nerves[12] there is the *autonomac* nervous system, so called because it is largely *automatic*. It has connections with the spinal cord, but is capable of controlling heart rate, intestinal motion and other organ (visceral) function without those connections. This automatic nervous system is composed of groups of fibers and nerve cells lying in front of the spine, chiefly in the chest and abdominal cavities. These structures are grossly visible, but the pattern is irregular and variable in contrast to the pattern of the central nervous system and peripheral nerves.

Cranium and Spine

A covering of bone has been provided for protection of the brain and spinal cord. The dome (vault) of the skull is formed by the frontal, temporal, parietal and occipital bones. The junctions are known as sutures and can readily be seen when the skull is exposed. The *sutures* are composed of serrated bone margins accurately approximated by nature without actual *bone union*. Except in the young (under six years) the sutures are rarely spread apart by either injury

9. *Vagus nerves:* (L. "wandering") The tenth cranial nerves which have a long course and extensive distribution in the body, having both sensory and motor elements, and supplying larynx, lungs, heart, esophagus, stomach and most of the abdominal organs.

10. *Sciatic nerve:* A large nerve which runs deep in the buttock area downward and supplies sensation and motion to skin of the leg, and muscles of the thigh, leg and foot. Among its branches are the articular, muscular, external and popliteal nerves.

11. *Cranial nerves:* Any peripheral nerve directly connected with the brain. There are twelve pairs of cranial nerves and their distributions and functions are well known. The fact and locus of injury or disease can be established by appropriate neurological examination.

12. *Peripheral nerves:* Nerves which supply peripheral parts of the body. Such nerves have the power of regenerating when cut; this is to be contrasted with lack of regenerative power in nerve cells completely contained within the brain or spinal cord; if these are destroyed they cannot regrow and the physiologic loss is permanent.

or increased intracranial pressure,[13] but in the young they may be separated by either condition.

In all, 22 bones unite to form the head. Six are single and symmetrically placed. Eight are duplicated. Except for the lower jaw (mandible), which joins the skull at a temporomandibular joint on each side, the bones are fixed in firm apposition as a single piece or unit.

The spinal cord is protected behind by the posterior arches of the vertebrae and by the spinous processes which extend backward from these arches. It is the tips of the spinous processes which give the center line of the back its characteristic appearance of successive oval knobs. Large muscles, one to three inches in thickness, overlie the arches of bone protecting the spinal cord. This same group of spinal muscles attaches to the back of the base of the skull and protects the lower part of the *medulla oblongata.*[14] The vertebral bodies, which are in front of the spinal cord, are separated by cartilage pads (intervertebral discs). These pads are of considerable thickness and constitute approximately 1/4 to 1/3 of the length of the spinal column. The pads consist of fibrous cartilage and act as joints between the vertebral bodies. The outer tough portion of the intervertebral disc is termed the *annulus fibrosus.* It serves to lash the margins of the vertebral bodies firmly together and also acts as an outer casing to prevent the escape of the soft cartilage (*nucleus pulposus*) from within the intervertebral disc. Motion is permitted in various degrees and directions in different portions of the spine, as one can determine by his own body movements. The vertebral arches open and close in flexion and extension of the spine. There are two joints (posterior articulations), one on each side, which determine the movement between these arches.

Of the seven cervical vertebrae, the upper two differ from the remainder in ways which adapt them for their attachment to the skull. The 12 thoracic (dorsal) vertebrae are so called because of the ribs which attach to them. Variations of the ribs in either form or number (one more or one less) are common. The unusual formation may occur at either extremity of the dorsal spine. Various degrees of cervi-

13. *Intracranial pressure:* Pressure of the cerebrospinal fluid which circulates around the brain and spinal cord and can be measured by a manometer during performance of a lumbar puncture, a simple and relatively riskless procedure whereby a hollow needle is inserted into the spinal canal, usually between the third and fourth lumbar vertebrae, under local anesthesia, below the level of the spinal cord. The examiner is able thus to obtain samples of the spinal fluid to study its color (for blood), contents (protein, bacteria, etc.), specific gravity, etc., as well as determine whether the pressure is normal or excessively elevated (suggesting a space-filling intracranial lesion such as an expanding brain tumor or a blood clot).

14. *Medulla oblongata:* The truncated cone of nerve tissue continuous above with the *pons* and below with the spinal cord. It contains vital centers for regulating respiration and heartbeat.

cal rib formation[15] are so common that critical appraisal is required to evaluate the significance of these variations. In general, when anomalies (variations of development) of bones have been demonstrated by x-ray, the medical profession, the legal profession and the laity are all too ready to accept these variations as being the cause of a particular patient's complaints.

The lowest of the five lumbar vertebrae (occassionally four or six) articulates with the sacrum,[16] which, with the two hip (or innominate) bones, forms the pelvis. The force which comes to rest on the lumbosacral joint[17] when a person lifts in a bent forward position may be as much as *ten* times the weight lifted (moments of force). In addition, this joint has the anatomical disadvantage of being the connection between a movable and a fixed structure (the spine moving on the pelvis).

Before describing the brain and spinal cord in more detail, their coverings should be mentioned briefly.

The Meninges[18]

Beneath the bony covering of both the brain and spinal cord there is a tough, fibrous membrane about 1/32 of an inch thick, the *dura mater*. It is well supplied with blood vessels, especially over the sides of the brain. It is an important barrier against infection. The middle meningeal artery grooves the skull constantly and may even tunnel through the temporal bone.[19] For this reason the middle meningeal artery may be found to be torn in fracture of the side of the skull and may rapidly produce an accumulation of arterial blood between the cranium and the dura mater with a fatal increase in intracranial pressure. If he has the opportunity, the neurological surgeon can usually preserve the life of a patient whose brain has not been severely injured and whose serious symptoms are due to the extradural hemorrhage. The neurological findings characteristic of this dramatic condition will be discussed later.

The *subdural space* normally is a potential space represented only by apposition of the *arachnoid membrane* to the undersurface of the dura mater. This space is important because in it a *subdural hema-*

15. *Cervical rib formation:* An extra rib occurring in the cervical or neck region; it may or may not produce symptoms.

16. *Sacrum:* The triangular bone situated at the base of the spine and formed of five united sacral vertebrae wedged in between the two innominate (hip) bones.

17. *Lumbosacral joint:* The articulation, or joint, between the lowermost lumbar vertebra and the sacrum in the low back region.

18. *The meninges:* The three membranes that envelop the brain and spinal cord, named from without inward the *dura mater*, the *arachnoid* and the *pia mater*.

19. *Temporal bone:* One of the constituent bones of the skull or cranium located at the side of the head, in front of the ear (the temple region).

toma[20] may accumulate. If this does occur, it usually becomes apparent in a period up to several weeks after a definite head injury. At other times there is no record of important injury and the accumulation of blood in the subdural space is rightly or wrongly attributed to trivial injuries which have occurred as long as a year before.

The *meninges,* as the term is used in regard to meningitis,[21] are constituted by both the membrane closely adherent to the brain (the *pia mater*) and the outer membrane (the arachnoid), which underlies the dura mater. These are joined together by irregular processes of the arachnoid. Within this space the cerebrospinal fluid normally circulates. The space is wide in the area about the normal spinal cord. There are large lakes (cisternae) of cerebrospinal fluid around the cerebellum and *brain stem* (the two inch column of brain beneath the cerebellum which is an upward continuation of the spinal cord). Over the surface (convexity) of the cerebrum the fluid space is quite thin except where the deeper fissures separate certain cerebral convolutions.[22]

Beneath the pia mater are the functioning cells of the nervous system (gray matter). In summary, we will proceed from these cells outward. The pia mater is a tough, thin, fibrous membrane which holds the soft functioning and supporting elements of the brain in the shape which we consider characteristic of it. Between the pia mater and the arachnoid there is a clear, colorless watery fluid — the cerebrospinal fluid. The pia mater and arachnoid are joined by tiny pillars of fibrous tissue which hold the arachnoid to the pia mater even when the dura mater has been stripped away. Because of this intimacy the pia mater and arachnoid are often called the *pia-arachnoid.* The subdural space, only a *potential* space, separates the arachnoid from the dura mater. Now, past the dura mater, we encounter the skull, the pericranium (periosteum[23] surrounding the bony skull) and then the temporal muscle, if in the temporal region. The next outward layer is the scalp proper. It is composed of the *galea aponeurotica* (an inner layer of fibrous tissue containing some muscle, especially in the forehead region, where it serves to wrinkle the forehead), a middle layer of fat rich in arteries and veins, and an outer layer of skin. The

20. *Subdural hematoma:* A blood clot underneath the dura mater.

21. *Meningitis:* Inflammation of the meninges, or membranes, which surround the brain. When it affects the dura mater, the disease is termed *pachymeningitis;* when the arachnoid and pia mater are involved, it is called *leptomeningitis,* or meningitis proper. In Eller v. A. C. Lawrence Leather Co., 222 N.C. 23, 21 S.E.2d 809 (1942), the court affirmed an award of the workmen's compensation commission finding that claimant had a permanent disability resulting from *hemorrhagic pachymeningitis* caused by an accident which arose out of and in course of employment.

22. *Cerebral convolutions:* The folded surfaces of the cerebral hemispheres. The convolutions greatly increase the surface area of cells which constitute the cerebral cortex or gray matter.

23. *Periosteum:* The tough fibrous membrane surrounding a bone and from which new bone cells are laid down in the course of repair of injured bone.

galea strips easily from the deeper layers and was included in the aboriginal scalping procedure.

The Brain

The cerebral hemispheres are masses composed of the gray cortex (nerve cell bodies) overlying the white matter (axons). Their bulk is approximately 3/4 that of the entire brain. A deep cleft (longitudinal fissure) separates the two cerebral hemispheres. The *falx cerebri,* a sickle-shaped portion of dura mater, dips into this fissure or cleft and serves to resist the encroachment of one hemisphere upon the other when the head is injured. Another sheet of dura mater separates the posterior cerebral hemispheres (occipital lobes) from the cerebellum which lies beneath them. This, the *tentorium cerebelli,* further subdivides the cranial cavity into compartments. It leaves a circular opening in front near the base of the skull (*tentorial notch*) through which the brain stem connects with the diencephalon (basal gangliar region underlying the cerebral hemispheres).

The brain is divided into *convolutions* (gyri) by fissures (which are deep) and sulci (which are shallow clefts). The broad sections are roughly named according to the bone beneath which the "lobe" is harbored as frontal, temporal, parietal and occipital lobes. The temporal lobe is clearly demarcated by a deep cleft through which pass the most important branches of the internal carotid artery (fissure of Sylvius). The frontal lobe is separated by a shallower cleft (fissure of Rolando) behind which lie the parietal and then the occipital lobes.

The importance of the *dominant* hemisphere must be stressed before describing the five fundamentally established centers of the cerebral hemispheres. Both the ability to speak and the ability to interpret *incoming* messages rest, in right handed persons, in the *left cerebral hemisphere.* In the left handed or in the ambidextrous individual the right hemisphere may or may not be the dominant hemisphere. Even in complete left handedness the presence of the speech and interpreting center in the right hemisphere is not positively assured. *Speaking* is as much a *motor* function of the brain as running or jumping. Speech is discussed along with the interpretation of incoming messages to the brain *because most of the ability to understand, think and act* resides in the dominant (usually *left*) hemisphere of the cerebrum and is closely associated with speech. Neurologically, we speak of *motor aphasia*[24] (inability to say words), *anomia* (inability to name ordinary

24. Traumatic aphasias involve considerable impairment of personality and usually substantial disability. They may involve actual or apparent impairment of mental function. Such patients make a great impression upon juries. About eighteen months ago a railroad brakeman, suffering from aphasia allegedly produced by head trauma from a flying brake shoe, obtained a jury verdict for $200,000 in the Federal District Court in New Orleans. Subsequently the case was compromised for $100,000.

objects), *alexia* (inability to read), *agraphia* (inability to write), *auditory aphasia* or word deafness (inability to *understand* the spoken word), and so forth. The term *visual agnosia* expresses the lack of ability to understand the meaning of things one sees clearly. The term *apraxia* is used to express the deficit when thought cannot be put into simple action. The *apraxic* patient may err in trying to put one shoe over the other, leaving the other foot unshod, or in trying to smoke a match and strike a cigarette. *He responds in an alert manner, but gives the wrong response. Perseveration,* the act of doing over and over some prior act, rather than performing the next act ordered and re-ordered, is a phase of *apraxia* easily recognized.

One can see that it is scientifically relevant, and probably important in jury trials to specify exactly the nature and scope of the interference with the speech functions. One must also consider whether the difficulties are due to brain tumor, cerebral hemorrhage, thrombosis (clot blocking blood vessel) or other competent producing cause rather than traumatic injury. Speech may be impaired or lost through injury of the speech center in the brain or through other mechanisms or injuries.

For cases involving alleged impairment of speech by head injury, see Pittsburgh, C., C. & St. L. Ry. v. Friend, 194 Ind. 579, 142 N.E. 709 (1924); Public Utilities Co. v. Handorf, 185 Ind. 254, 112 N.E. 775 (1916) (both jaws fractured and lower jaw paralyzed destroying power of speech); Nordin v. Lovegren Lumber Co., 80 Ore. 140, 156 Pac. 587 (1916); Kirby Lumber Co. v. Youngblood, 192 S.W. 1106 (Tex. Civ. App. 1917); Druska v. Western Wis. Tel. Co., 177 Wis. 621, 189 N.W. 152 (1922) (face badly cut causing drooping of mouth and impediment of speech).

Injury to facial nerve causing paralysis of side of face or of lip, resulting in impairment of speech: Ozan Graysonia Lumber Co. v. Ward, 188 Ark. 557, 66 S.W.2d 1074 (1934); Snyder v. Tanner Motor Livery, Ltd., 50 P.2d 1051 (Cal. App. 1935); Sponable v. Thomas, 139 Kan. 710, 33 P.2d 721 (1934). Paralysis or injury to vocal cords causing impairment of speech: Seaboard Airline Ry. v. Watson, 94 Fla. 571, 113 So. 716 (1927); Thirkell v. Equitable Gas Co., 307 Pa. 377, 161 Atl. 313 (1932). Neurotic and psychic mechanisms: Stark v. Yellow Cab Co., 90 Cal. App.2d 217, 202 P.2d 802 (1949) (halting speech mannerisms caused by traumatic neurosis); Warren v. Giudici, 330 Mo. 483, 50 S.W.2d 634 (1932) (fracture of jaw bones); Gallo v. American Egg Co., 72 A.2d 166 (R.I. 1950) (nervous shock aggravating and increasing pre-existing stutter); Zeinemann v. Gasser, 251 Wis. 238, 39 N.W.2d 49 (1947) (manner of vocal expression and speech changed).

Miscellaneous cases: Woodward v. City of Waterbury, 113 Conn. 457, 155 Atl. 825 (1931); Schneiderman v. Interstate Transit Lines, Inc., 326 Ill. App. 1, 60 N.E.2d 908 (1945) (permanent aphasia in 35 year-old policeman; verdict and judgment for $100,000 reversed; plaintiff's injuries rendered him incompetent), *reversed and remanded,* 394 Ill. 569, 69 N.E.2d 293 (1946), *trial judgment aff'd,* 331 Ill. App. 143, 72 N.E.2d 705 (1947), *aff'd,* 401 Ill. 172, 81 N.E.2d 861 (1948); Northern Indiana Public Service Co. v. McClure, 118 Ind. App. 680, 81 N.E.2d 706 (1948) (impediment in speech attributed to injury of central nervous system from carbon monoxide poisoning); Jones v. Kasper, 109 Ind. App. 465, 33 N.E.2d 816 (1941) (permanent loss of speech); Deffenbaugh v. Inter-state Motor Freight Corp., 254 Mich. 180, 235 N.W. 896 (1931) (brain injury); Koestler v. Burton, 207 Miss. 40, 41 So.2d 362 (1949) (lisp); Belding v. St. Louis Public Service Co., 358 Mo. 491, 215 S.W.2d 506 (1948) (speech difficulty); Rush v. Thompson, 356 Mo. 568, 202 S.W.2d 800 (1947) (tremor of tongue affecting speech); Murphy v. Fred Wolferman, Inc., 347 Mo. 634, 148 S.W.2d 481 (1941) (thickness of speech as result of brain injury); Gillis v. Singer, 86 S.W.2d 352 (Mo. App. 1935); Wilson v. Spuhler, 20 S.W.2d 556 (Mo. App. 1929); Cherry v. Nusbaum, 299 Pa. 91, 149 Atl. 110 (1930); Dalls Ry. & Terminal Co. v. Farnsworth 231 S.W.2d 518 (Tex. Civ. App. 1950) (speech block); Handley v. Anacortes Ice Co., 5 Wash.2d 384, 105 P.2d 505 (1940) (11 year-old boy; injury to speech center).

All that we do is *motor*. If we run, speak, change our facial expressions, bat our eyes, or indicate anything to others, we are exercising the *motor* centers of the cerebrum, invariably using, too, the important motor centers *below* (diencephalon, brain stem, spinal cord) to give smooth effective movement. The cerebral motor centers, without help from diencephalon, brain stem and cerebellum, can produce only irregular, erratic, ineffectual movements. Without the continuity of the pathways from the cerebral motor centers to the spinal cord only reflex movements are possible.

Speaking and understanding — motor (efferent) and sensory (afferent) functions — have been discussed first both because of their importance and because of their localization in the dominant cerebral hemisphere. The motor function has been stressed since, if we include speech, it represents the total *output* of the individual. We will, then, place the *motor center* as the first and most important cerebral center. It lies in a strip which extends transversely across the cerebrum in front of the fissure of Rolando. Simple movements are initiated by the area bordering on the fissure of Rolando, and the more forward area contributes to the organization of simple movements into more complex patterns. Leg, arm, facial and speech movements are arranged from above downward. Many movements, such as closure of the eyelids and swallowing, can be satisfactorily accomplished from *either* cerebral hemisphere with no help from the other. In contrast, arm and leg movements are dependent upon the *contralateral* cerebral hemisphere.[25] Trunk movements also have *bilateral* representation in the cerebrum, and one *intact* hemisphere can take over movements of the trunk moderately well after a period of adjustment.

Sensory Centers of the Cerebrum

Incoming nerve fibers, destined for the cerebrum, have many side connections in the more primitive centers below. The head and eyes may be turned toward a sound or toward a moving object before the noise or image enters cerebral *consciousness*. However, when sensations do reach one's consciousness, it is through well-known channels and to a particular cerebral area.

Five structurally different areas of the cerebral cortex perform well-known functions. The first, the *motor area*, has been outlined. The four *sensory* (or receptive) *areas* remain to be described. Vision is received in the portion of the occipital cortex which faces the midline

25. *Contralateral cerebral hemisphere:* The cerebral hemisphere opposite to the arm or leg motivated by it. The right hemisphere of the brain controls arm and leg movements on the left side of the body; the left cerebral hemisphere controls such movements on the right side of the body. This is a fact which sometimes betrays the malingerer ignorant of anatomic arrangements. See Keschner, *Simulation of Nervous and Mental Disease*, 103 J. OF NERV. AND MENT. DIS. 571 (1946), 44 MICH. L. REV. 715 (1946).

at the back. Hearing reaches consciousness in a small area deep in the Sylvian fissure.[26] The sensation of *form* and *quality* of objects which are *touched* is perceived in the cerebrum in the area immediately *behind* the motor area.[27] Taste and smell are perceived in a portion of the cerebral cortex on the under-surface of the temporal lobe.[28] Hearing, smelling and tasting are almost never appreciably altered by a unilateral *cerebral* lesion (destructive pathological process) because of the division of function between the two sides.[29]

In contrast, destruction of the *right* occipital cortical area will bring about the loss of vision to the *left* of the vertical meridian (through the point of central vision) in both eyes.[30] In other words, if a car approached on the left, it would not be detected until it came to the center (vertical meridian) of the visual field. Similar right field blindness results from damage to the left visual cortex. Most of the visual pathways are well known and other remarkable patterns of visual field loss are frequently observed. Visual field loss on one side is often overlooked by the patient. Its detection is of great value in neurological diagnosis.

The cortical sensory area contributes chiefly to interpretative sensation. The sensory messages are received in the cerebral hemisphere on the opposite side from the extremities in which they originate. Loss of the cortical sensory area does not interfere with crude appre-

26. For cases involving alleged impairment of hearing by trauma, see Notes, 16 A.L.R.2d 3, 204 *et seq.* (1951), 102 A.L.R. 1125, 1337 *et seq.* (1936), 46 A.L.R. 1230, 1320 *et seq.* (1927).

27. *Astereognosis:* Landgraf v. United States, 75 F. Supp. 58 (E.D. Pa. 1947) (loss of ability to recognize shapes of objects with left hand; laceration of brain and multiple injuries decreasing earning power of marine carpenter by 40%; $53,253.02 awarded by court).

28. *Taste:* Power v. California Street Cable R.R., 52 Cal. App.2d 289, 126 P.2d 4 (1942); Blanke v. Miranne, 11 So.2d 264 (La. App. 1942).

Smell: See Notes 16 A.L.R.2d 3, 352 (1951); 102 A.L.R. 1125, 1540 (1936); 46 A.L.R. 1230, 1408 (1927). California courts have upheld much larger awards than other jurisdictions. See Duvall v. Transcontinental & Western Air, 98 Cal. App.2d 106, 219 P.2d 463 (1950) (loss of sense of smell in baker, with other injuries; $35,000 held not excessive); Potter v. Empress Theatre Co., 91 Cal. App.2d 4, 204 P.2d 120 (1949) ($30,000 for loss of sense of smell with other injuries).

29. The litigation involving alleged impairment or loss of smell (anosmia) as a result of trauma exceeds that involving alleged impairment or loss of taste (ageusia). This may be because the first (anosmia) may occur from falls or blows which cause the brain to move within the cranium in such a way as to tear off the fine nerve filaments which pass downward from the olfactory bulbs through the cribriform plate at the base of the skull into the nose. These filaments carry the sense of smell. Fractures are common in the floor of the front part of the cranial cavity and commonly involve the olfactory pathways on both sides. The patient with anosmia usually complains of loss of taste which, in regard to food, is largely olfactory.

30. This is because the nerve tracts subserving vision run forward in each hemisphere with the outer bundles continuing to the outer (temporal part) of the eye on the same side while the inner bundles cross in the optic chiasm and run to the inner side (nasal aspect) of each eye. For cases involving impairment or loss of vision, see Notes, 16 A.L.R.2d 3, 130 *et seq.*, 419 *et seq.* (1951), 102 A.L.R. 1125, 1258 *et seq.* (1936), 46 A.L.R. 1230, 1281 *et seq.* (1927).

ciation of touch, pain, heat and cold (which are appreciated in the thalamus).[31] However, objects cannot be identified by their shape, size and texture (*astereognosis*). Often the patient is even unable to identify the finger or toe which is firmly held by the examiner, even though he clearly feels the pressure.

The Spinal Cord

The spinal cord consists, in contrast to the cerebrum, of white matter surrounding the central gray matter. The white matter is composed of tracts or groups of fibers passing to (afferent) and from (efferent) the brain. The gray matter is composed of cells which relay these afferent or efferent messages. These connections are known as synapses. The cells of the central gray matter are not normally capable of independent activity, but numerous reflexes (movements without thought) can be brought about by impulses that reach them without reaching the brain or consciousness.

The spinal cord extends from the brain to the first lumbar intervertebral disc. From it arise pairs of nerves destined to pass to each side through intervertebral foramina (openings). There are as many pairs as there are spaces. Since there are numerous pairs of foramina below the termination of the spinal cord it is apparent that the sections (segments) of the spinal cord corresponding to the lower pairs of nerves are crowded into the spinal canal *above* the termination of the spinal cord. The lower part of the sac composed of the dura mater and arachnoid contains the lumbosacral nerves (cauda equina), bathed in cerebrospinal fluid. The sac terminates within the sacrum. A single nerve origin will be described to illustrate the position of the spinal cord segments. The fourth lumbar pair of nerves originates from the fourth lumbar spinal cord segment which is lodged within the spinal canal at the level of the eleventh thoracic vertebra. They descend as part of the cauda equina (horse's tail) to emerge laterally through the paired foramina between the fourth and fifth lumbar vertebrae.

From two enlargements of the spinal cord, the cervical and the lumbar enlargements, originate the nerves which form the brachial[32] and the lumbosacral plexuses[33] respectively. The size of the nerves con-

31. But the loss of fine discrimination involves substantial impairment of one's safety factors.

32. *Brachial plexus injury*: See Fitzgerald v. State, 198 Misc. 39, 96 N.Y.S.2d 452 (Ct. Cl. 1950) ($53,889.27 upheld); Henwood v. Moore, 203 S.W.2d 973 (Tex. Civ. App. 1947) ($20,000 upheld for injury to right brachial plexus). The brachial plexus of a baby may be injured in difficult obstetrical cases. Penetrating wounds of the axilla (arm-pit), or injuries in which there is severe traction upon the arm, shoulder or neck may produce partial or complete injury to the brachial plexus.

33. *Lumbosacral plexus*: The lumbar, sacral and pudendal plexuses of nerves together. This plexus is not so exposed or susceptible to injury as is the brachial plexus. See Note, 16 A.L.R.2d 311 *et seq.* (1951).

tributing to these important plexuses which supply the upper and lower extremities is greater than those supplying the trunk.

Physiology

It would be interesting to have better correlation between the mental capabilities of genius and the anatomical configuration of the cerebrum. We actually have little, but we remain receptive to new attempts at correlation despite past failures. The components of genius — memory, judgment, analytic ability and drive — remain as yet unlocalized in the cerebral hemispheres. Nevertheless, the large "silent" areas, whose specific functions are undetermined, must be in large part preserved for superior intellectual ability to exist. When potential abilities are present, their application rests in no small part upon the coincidences of environment and circumstances. Fortunately, knowledge is more complete in certain phases of vertebrate physiology which can be discussed more objectively. First, the function of parts of the human brain which are common to all mammals and which are represented in much lower forms must be mentioned.

The basal ganglia (nerve cell masses underneath the cerebral hemispheres) connect above with the cerebrum and below with the brain stem.[34] This portion of the nervous system is very little different in lower forms and in man. There are many connections with the nerves of smell (olfactory nerves). The olfactory impulses greatly influence the activities of the lower animals, but their loss in man results largely in an impairment of the pleasure of enjoying good food.[35] Nevertheless, there is an important medico-legal aspect in that illuminating gas becomes odorless to the patient and asphyxiation from it becomes a greater hazard.[36]

In the lower animal forms the ability to perform many functions rests upon the intact diencephalon (basal gangliar region) and brain stem. Man, in the development of the cerebral hemispheres, has lost much of his ability to perform when only the primitive nervous system is left intact. Nevertheless, consciousness in man is lost as irreparably from severe damage to the brain stem or diencephalon as from damage to the cerebral centers discussed above.

The abode of consciousness is unknown, but consciousness cannot be maintained with too extensive a brain stem or basal gangliar injury or with diffuse, severe damage to the cerebral hemispheres.

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34. Thus the important nerve bundles passing from the cortex to the brain stem have important connections with the basal ganglia, which, among other things, help convert crude jerky movements into fine, discriminating movements.

35. See note 29 *supra*.

36. This involves loss of a safety factor which is a compensable "psychic" injury. See Smith, *Psychic Interest in Continuation of One's Own Life: Legal Recognition and Protection,* 98 U. OF PA. L. REV. 781 (1950).

Survival is possible, even in man, with only a small segment of the nervous system left intact. The medulla oblongata with its connections (by way of the cervical spinal cord) to the fourth cervical segment can maintain life temporarily with no help from or connection with other parts of the central nervous system. The fourth cervical segment of the spinal cord is of vital importance because it contains the cells of origin of the phrenic nerves, which motivate the diaphragm.[37] This minimal unit is formed by the medulla oblongata which produces the respiratory impulses and by the upper part of the cervical spinal cord through which the impulses are transmitted to the phrenic nerves to bring about rhythmic contractions of the diaphragm. The vagus nerves which connect the medulla oblongata with the autonomic (automatic) nervous system are not essential to temporary survival, but, if intact, will partially control heart function. Most of the cells of the body can remain temporarily alive if artificial respiration is effected, even though there is *total arrest* of central nervous system (brain and spinal cord) function. Arrest of nerve cell function may be temporary after concussion (agitation) or after oxygen deprivation (as in drowning or asphyxia). If the insult is too great, the arrest of function is said to be "irreversible" because the nerve cells (neurons) are irreparably damaged.

With loss of cerebral function, but with preservation of the upper brain stem (pons varoli and midbrain) in addition to the medulla oblongata, more prolonged survival is possible. If the hypothalamus (the area beneath the thalamus) and other centers in the basal gangliar region (diencephalon) are preserved, reflex function (of which the person is unconscious) of varied types may be possible. The suck reflex, automatic crying and swallowing, and even stretching or yawning may be present. Life may continue indefinitely if no complication (usually lung infection) supervenes.

The activities possible in man without the cerebrum represent a very small fraction of the possible activities of similarly "decerebrate" lower forms. The frog's activity is little changed, therefore, for there was little cerebrum to sacrifice. The dog can walk and eat, but will definitely be altered in his behavior. The monkey will be paralyzed, but not nearly so severely as man.

The *cerebellum* is a large brain mass in the back portion of the cranial cavity overlying the medulla and pons. Its function is coordination of muscle movement, and it works with many of the nerve cell groups (ganglia) of the brain stem. Strangely enough, it can, without producing serious symptoms, harbor large tumors. (It is the commonest *single* site of brain tumors in children.) The lateral mass (hemi-

37. *Diaphragm*: The dome shaped muscle which separates the abdomen from the chest cavity (thorax) and has an active part in respiration.

sphere) on each side helps to control the coordination on the same side of the body. The cerebral hemisphere controls the opposite (contralateral) side of the body because of a single crossing (decussation) of tracts. The cerebellar hemisphere aids in coordination of the same side of the body because of a *double* crossing. The middle portion (vermis) of the cerebellum coordinates walking. Great judgment must be exercised in the evaluation of symptoms which may point to cerebellar disease.[38]

The Cerebrospinal Fluid Circulation

The function of the cerebrospinal fluid is not altogether clear, but it certainly serves well in several capacities. The brain is relatively "floated" in the 160 cc. of fluid which are normally present. Beneath the vital brain stem and hypothalamus, the fluid channels (basilar cisternae) are deep (1/4 to 1/2 of an inch) and serve to cushion these important centers when the head is severely shaken (concussed). The spinal cord is completely surrounded by a fluid space of 1/8 to 1/4 of an inch which cushions it for vertebral motions and jars. The convexity of the cerebrum is covered by only a thin fluid layer except over the deeper fissures.

In addition to the fluid spaces outside of the brain there are fluid-containing cavities within the brain itself — the ventricles. Even the spinal cord has a central canal which contains a negligible amount of fluid, probably serving no useful purpose in man.

There are normally four ventricles within the brain, two lateral ventricles (first and second in the original naming, but alike, and called "right" and "left"), a third ventricle which separates the basal ganglia, and a fourth ventricle which is a fluid space above and behind the medulla oblongata, separating it from the cerebellum which overlies it. The fourth ventricle receives its fluid from the third ventricle through a narrow (1/8 of an inch) channel through the midbrain (the aqueduct of Sylvius). Fluid passes to the cisternae and other "outer" spaces by minute openings which may be obliterated in diseases such as meningitis (the two lateral foramina of Luschka and the midline foramen of Majendie).

Cerebrospinal fluid is formed in all four ventricles by the *choroid plexus*. The most significant secretion is in the two lateral ventricles. The fluid which is secreted flows to the third ventricle through the interventricular foramina. Additional small amounts of fluid are secreted within the third and fourth ventricles. From the third ventricle this fluid flows through the aqueduct of Sylvius to the fourth ventricle,

38. It is obviously important to determine through appropriate examinations the origin of the lesion, whether caused by disease or injury, its location and its degree. Observe that many lesions involve total and permanent disability while yet permitting continuance of life into the indefinite future.

thence to the remainder of the fluid system as described.

The process of "formation" or "secretion" of the cerebrospinal fluid is poorly known, but is said to result from filtration and osmosis. Secretion, as of a gland, is thought by some to occur. In normal people the chemical constituents are remarkably constant and the examination of fluid removed from the lumbar subarachnoid space is extremely important in the diagnosis of syphilis, meningitis, multiple sclerosis[39] and many other conditions.

The cerebrospinal fluid is assumed to be circulating continuously from its point of origin in the lateral ventricles (and, to a less extent, in the other two ventricles) through the third ventricle and aqueduct of Sylvius to the fourth ventricle, thence to the cisternae. Absorption of the cerebrospinal fluid is thought to occur essentially over the convexity of the cerebrum through special arachnoidal organs extending into the blood spaces (dural sinuses) within the dura mater.

This complicated circulation has been described not only to account for the protective layer of fluid, but also to give a background to explain other common conditions. For example, a small tumor which *obstructs* the aqueduct of Sylvius produces a gigantic fluid mass in the lateral and third ventricles, within which the cerebrospinal fluid is blocked. Such an accumulation encroaches upon brain tissue and may destroy parts of it. The circulation of the cerebrospinal fluid is so necessary to life that any obstruction along the pathway from point of origin to point of absorption may prove fatal.

The accumulation of large quantities of cerebrospinal fluid within the brain is known as *hydrocephalus.* Mere *enlargement* of a baby's head may be due to tumor, subdural hematoma[40] or other cause. The usual hydrocephalus, due to accumulation of excessive cerebrospinal fluid without obstruction of its flow, is thought to result from oversecretion or under-absorption, but is not well understood. There is, then, no obstruction between the ventricles of the brain and the spinal fluid space in the ordinary "communicating hydrocephalus." Surgical efforts have not been especially helpful in this condition.

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39. *Multiple sclerosis*: A degeneration of nerve tracts occurring in sporadic patches throughout the brain or spinal cord, or both. Among its symptoms are weakness, incoordination, strong jerking movements of the legs and especially of the arms, abnormal mental exaltation, scanning speech. It is at present considered incurable, and may last for many years. Dr. Moses Keschner, Professor of Clinical Neurology at Columbia, who speaks from an enormous experience, has recently concluded that, according to his findings, "a severe trauma to the head or spinal column may aggravate the course of multiple sclerosis" as may infections, pregnancy and child-birth (parturition). See Keschner, *The Effect of Injuries and Illness on the Course of Multiple Sclerosis,* 28 ASS'N FOR RESEARCH IN NERVOUS AND MENTAL DISEASE ON "MULTIPLE SCLEROSIS AND THE DEMYELINATING DISEASES" (1950). Conclusions as to aggravation by injury of a disease with so varied a course must be reached with great caution.

40. *Subdural hematoma*: A blood clot beneath the dura mater. This might be due to head injury occurring at any age.

GENERAL MEDICO-LEGAL ASPECTS OF THE NERVOUS SYSTEM

The brain presides over the subservient members of the nervous system, the most specialized and complex of all the organ systems; yet, as Dr. Broca, a French physician, discovered in the last century, the brain itself can be lacerated without appreciation of pain, because the brain tissue has no sensory receptors. This is a rather remarkable fact, inasmuch as the sensory tracts in the brain receive and interpret incoming messages signalling the pain and sensation picked up by receptors in other parts of the body and transmitted inward over the nerves and the spinal cord. The brain is insensitive to traumatic stimuli imposed upon it but not to the stretching or torsion of its large blood vessels. However, the brain, with its special tracts is adapted to appreciating and interpreting sensory impulses, including pain, transmitted from the periphery. In recent years, Dr. Harold G. Wolff of New York City and his associates have been studying the pain threshold in man.[41] They have used an instrument called the *dolorimeter* in studying the amount of heat barely sufficient to produce a painful sensation in the test subject. Out of the work has come confirmation of the fact that reception of pain and reactions to the experience must be differentiated. It would seem that in all persons, the pain threshold, or the efficiency of sensory receptors, tends to be substantially the same under identical conditions. The interpretation of the experience occurs in the brain and seems to depend largely upon the personality pattern, the conditioning and the reactivity of the subject. In an article prepared for the First National Symposium on Scientific Proof and Relations of Law and Medicine, Dr. Hardy, Dr. Wolff and Miss Goodell made the following observations concerning the medico-legal implications of pain threshold, namely:

> "A subject's pain threshold can be measured, and predictable results can be attained under fixed conditions. Yet the value of such information in the ascertainment of the proper compensatory damages to be awarded is limited.
>
> "In the first place, a normal pain threshold may be found in persons with serious damage to the nervous system, and as well in those with profound disturbance in personality function. Elevation of the pain threshold could have a number of meanings. The pain threshold may be raised because the nervous system in one part or another has been damaged, because of the action of an analgesic agent, or because the subject has a conviction, conscious or unconscious, that pain sensation has been impaired. A quantitative statement of an elevation in pain threshold, therefore, would be of slight value.
>
> "Lowered pain threshold is never due to structural disease of the nervous system. The latter, if it causes any change in the pain threshold will always raise the threshold. Thus, barring skin damage, a lowered pain thres-

41. Hardy, Wolff, and Goodell, *The Pain Threshold in Man,* 99 AM. J. OF PSYCHIAT. 744 (1943).

> hold in the plaintiff represents a reversible condition associated with anxiety, apprehension or malingering.
>
> "In short, an abnormally lowered pain threshold does define the general nature of the disability and may help shape judgment concerning proper compensatory award."[42]

Special books have been written both on pain and on headache, which may prove interesting and valuable to a lawyer who has a case involving these problems.[43] It may be relevant to note that headache apparently may be caused by injury of the scalp alone, by affecting the fine nerves which run in the walls of blood vessels; it is also now known that certain injuries to the soft tissues of the neck may be a factor in producing headache. It is well known that the normal healing processes, such as the regeneration of sensory nerves in a simple laceration, may cause annoying sensations which are interpreted by the patient as being unbearable. Conclusions must be reached by careful analysis of all data with the best possible knowledge of physiological and psychoneurotic factors. It is in this type of patient that supposedly purely objective findings often fail so miserably. A patient with organic nerve involvement may have an increased threshold to pain, and yet certain stimuli, ordinarily not productive of pain, may cause very distressing symptoms in such a patient.

The cells of the brain and spinal cord have attained their specialization and sensitivity, in the course of evolution, at the expense of ability to withstand noxious agents and to regenerate in case of destruction. The medulla oblongata, a part of the primitive brain stem, contains the lower indispensable centers for respiration and heartbeat. The cells of this older part of the brain are not as sensitive to noxious agents as are those of the cerebral cortex. Thus, a given amount of anesthetic may render a person unconscious by action on cells of the cerebral cortex without inactivating cells of the medulla oblongata. The same differential effects upon brain cells, dependent upon their variable sensitivity, follows deprivation of oxygen (anoxia) and ingestion of alcohol. If cells of the cerebral cortex are deprived of oxygen for any substantial period of time they may be irretrievably damaged and no regeneration will occur; if the person so affected survives, the end result will depend upon the extent of the cortical damage he has sustained. If this has been slight, there may be no perceptible effect on personality; if it has been sufficiently great, the person may be reduced to a vegetative existence in which he is unable to establish any intellectual contact.

Theoretically, each brain cell could possibly communicate with every other one and it is logical to assume that all parts of the brain have functions to perform. It is nevertheless true, as we have pointed out,

42. *Id.* at 750.
43. WOLFF AND WOLF, PAIN (1948); MOENCH, HEADACHE (1947).

that the brain contains only a limited number of highly specialized areas; the remainder of the tissue appears to carry on its function through less focal mechanisms so that as much as one centimeter of that tissue may be destroyed without causing perceptible effects on intellect or personality. The layman's superstition that if any part of the brain is damaged the victim will suffer dire results has not been borne out by scientific knowledge gained in World War I and World War II. In this connection it is important to remember that the symptoms resulting from brain damage will depend upon organic factors, upon the psychological reactions of the subject to his injury and upon possibilities of re-education and rehabilitation. Thus it has been demonstrated time and again that some persons who sustain gross destruction of brain tissue in automobile accidents make a rapid recovery with little or no perceptible change in intellectual functioning or personality; others, after sustaining slight organic damage, develop extensive disabilities in the form of traumatic neuroses or even traumatic psychoses. This has led to the important conception that the pretraumatic personality structure of the victim of a brain injury is exceedingly important in explaining the nature and degree of his reactions. In many instances, the individual was already a neurotic, or perhaps was either psychotic before the accident or was on the verge of such a state. It seems that the emotional stress of the situation rather than the organic damage sustained is responsible for development of many of the post-traumatic psychic disabilities. The plaintiff's lawyer may be able to substantiate causation of far-reaching effects by modest trauma by showing that his client previously had such a psychic vulnerability; defendant's counsel may be able to show that part or all of the claimant's symptoms existed prior to the traumatic episode, or, at best, were only aggravated by the trauma.

In the field of medicine, we speak of *signs* as involving abnormalities or pathological changes visible or detectible by a trained observer without reliance upon any history given by the patient. *Symptoms,* on the other hand, involve those subjective complaints which can be learned only through the story related by the patient. These involve such complaints as pain, headache, dizziness, impaired concentration, nausea and the like. One of the chief problems in evaluating disabilities imputed to trauma is to determine as precisely as possible the cause and extent of symptoms. Difficulties are increased by the fact that the same symptoms sometimes may be due either to organic injury of cells in the body or to purely psychological reactions. Since the latter should generally be of temporary duration, and may spring from personality conflicts or from causes unrelated to the traumatic episode, defense counsel must insist vigorously that the claimant specify the underlying cause of his symptoms in terms of accepted medical diagnostic nomen-

clature.[44] To attempt to award compensation for a symptom without knowing its producing cause involves a highly speculative and conjectural undertaking.

One of the first questions to be asked concerning any alleged neuropsychiatric disability is whether an adequate neurological examination has been made by a competent person. Although any account of what is involved in a well conducted neurological examination must be technical in some degree, we believe the value to the lawyer of knowing successive steps involved justifies an attempt to describe the procedure. A knowledge of what is customary may enable alert counsel to test the adversary's medical witness rigorously by cross-examination directed to searching out the adequacy of his knowledge and examinations.

THE NEUROLOGICAL EXAMINATION

In making a neurological examination it is necessary to note and record even questionable variations from the normal, as well as normal and abnormal findings. Regardless of whether or not the findings fit together they are recorded completely. Frequently there will be a picture complicated by psychoneurosis.[45] In such a case infinite patience is required to separate the organic abnormalities from the functional. Carefully detailed and repeated examinations will clarify many a tangled clinical picture which at first appears insoluble.

The History

Most of the routine neurological questions are included in a good inventory by systems. These are quickly covered except when there

44. The American Medical Association, and the various medical specialty boards, have developed a comprehensive list of accepted diagnoses. It is obligatory, in hospital practice, to use standard nomenclature in making diagnoses. Every known medical condition has an accepted diagnosis and certainty can only be achieved by insisting on the use of these in medico-legal litigation.

45. *Psychoneurosis*: Symptoms, which may or may not be disabling, representing a diffuse form of expression of underlying, unresolved emotional conflicts without any demonstrable lesion or injury of the nervous system. It does not involve any distortion of reality, being thus distinguishable from psychoses. As the emotional conflicts usually go back to childhood, one is always on guard to determine whether an alleged traumatic neurosis from physical or psychic trauma actually pre-existed the traumatic episode sought to be incriminated, or was produced by independent post-accident causes. Traumatic neuroses fall into two classes: about five-eighths follow minimal stimuli which would not affect an average person — these are declaratory of pre-existing neurotic personality and should be compensated modestly, if at all, and only on the theory of aggravation; approximately three-eighths follow serious trauma to persons of average physical and psychic resistance and when these facts are established it would seem proper to award substantial compensation. It should be noted, however, that traumatic neurosis usually involves temporary disability only; furthermore, there is no evidence that such a state is a halfway station toward development of insanity (psychosis) as some careless medical men have testified. See Smith and Solomon, *Traumatic Neuroses in Court*, 30 VA. L. REV. 87 (1943).

are positive findings which necessitate exhaustive questioning. Headings which have special reference to neurological diagnosis are indicated below with listing of certain points which require special questioning.

Head — Head injury: How caused; duration of unconsciousness or period of mental imbalance; period of retrograde amnesia (memory blank preceding injury); discharge of blood or cerebrospinal fluid; focal symptoms (indicating localized brain or cranial nerve damage); sequelae (subsequent symptoms or other impairment of function). Headaches: Precipitating cause; time of occurrence; duration; location; periodicity; character of the pain; results of treatment; concomitant symptoms (nausea, vomiting, visual phenomena, etc.).

Eyes — Vision; use of glasses; fullness of visual fields; diplopia (double vision)[46]; blurring; color vision; hallucinations; scintillating scotomata (sparkling spots).

Ears — Deafness; pain; discharge; tinnitus (ringing); vertigo (dizziness).

Throat — Hoarseness; dysphagia (difficulty in swallowing).

Genito-urinary — Frequency, day or night; dribbling; urgency; hesitancy; pain; retention; incontinence.

Neuro-muscular — Sleep; fatigability; tingling; numbness; weakness; tremor; loss of control over limbs; convulsions.

Spine — Injury, sequelae.

A careful family history with accurate description of relevant cases is taken. Inquiry into the use of alcohol or drugs or exposure to lead or other poisons is frequently important. If convulsive seizures or equivalents of any kind have occurred,[47] it becomes necessary to inquire minutely as to the following points: Exciting cause; tendency to greater or lesser frequency and severity; warning (aura); type of movement: tonic, clonic, purposive; starting point of movement; order of spread; injury from falling; biting of tongue; micturition (urination) or defecation; cyanosis, pallor or plethora; duration of attack; after-symptoms: coma, vomiting, headache, somnolence, or especially motor, sensory, or speech deficit.

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46. See references cited note 30 *supra*, for litigated cases.

47. The crucial question is whether the subject has idiopathic epilepsy antedating the traumatic episode or whether his convulsive seizures or equivalents were caused by head injury. Sub-pial irritation by blood may cause two or three seizures in the hospital which will not recur later; it is now generally accepted, therefore, that traumatic epilepsy should not be diagnosed unless the attacks recur after discharge from hospital.

The Examination

Below is given a description of the routine examination with normal findings and parenthetical explanatory remarks. Positive findings thus disclosed will frequently suggest other tests which are necessary to make the diagnosis. For a more detailed outline of the neurological examination one should consult a good textbook.[48] The form of recording a negative neurological examination follows:

Mental state — Well oriented, complacent, intelligent, cooperative. (Include especially ability of verbal expression, comprehension of spoken or written commands, and their execution. Test ability to name various objects.)

Head — No tenderness to pressure or percussion;[49] head flexes readily on chest. (Abnormality in size of head, irregularities, "cracked pot sound," dilated veins of scalp, etc., are noted if present.)

Cranial nerves—

I. (Olfactory nerve: Smell) Identifies odor of coffee and soap with either nostril.

II. (Optic nerve: Vision) Reads newspaper print with either eye. Fields full to gross testing (tested separately). Fundi[50] normal.

III, IV; VI. (Nerves to the muscles which move the eyeball — Oculomotor nerve, Trochlear nerve, Abducens nerve) Extra-ocular movements full in all directions. Convergence good. No nystagmus. (Nystagmus consists of an oscillatory movement, usually of both eyes, with the more rapid movement usually toward the side to which the eyes are directed. Serious congenital ocular defects are often complicated by nystagmus. Rotary nystagmus — actual rotation of the eyeballs — indicates disease, congenital or acquired. A few *nystagmoid* jerks may be considered normal.) No ptosis (drooping of eyelid). Pupils are round, regular, equal, two millimeters wide, react well to light and accommodation. No diplopia (double vision) on gazing in any direction.

V. (Trigeminal nerve: Sensory nerve to face; motor to jaw muscles) Corneal reflexes equal. No sensory changes to pin prick or cotton wool. Motor normal (masseter and temporal muscles contract well; no deviation of jaw on opening mouth).

VII. (Facial nerve: Motor nerve of face) No asymmetry or weak-

48. As, for instance, MONRAD-KROHN, CLINICAL EXAMINATION OF THE NERVOUS SYSTEM (9th ed. 1949).

49. *Percussion*: The act of striking a part with short, sharp blows as an aid in diagnosing the condition of the parts beneath by the sound obtained.

50. *Fundus oculi*: The posterior part or base of the eye, within its coats. Visible through an ophthalmoscope, an instrument having a perforated mirror or prism used in inspecting the interior of the eye.

ness. (Wrinkling forehead, closing eyes, retracting corners of mouth on volition and on smiling are tested.)

VIII. (Auditory nerve: Vibrating tuning fork heard equally on two sides. Weber's test not lateralized. Air conduction is appreciated better than bone conduction bilaterally.

IX, X. (Glossopharyngeal and Vagus nerves: Motor and sensory; swallowing, speech, digestive organs, etc.) Palate rises symmetrically on phonation. Palatal reflexes normal. (Soft palate touched with tongue blade on each side, retracts.) Swallows easily. Speech is clear and normal.

XI. (Spinal accessory nerve: Motor nerve to sterno-mastoid muscles in side of neck) No weakness. (Sterno-mastoids contract equally; shoulders shrugged equally.)

XII. (Hypoglossal nerve: Motor nerve to tongue muscles) Tongue protrudes in midline; no atrophy or fibrillations; rapid movements (lateralwise of slightly protruded tongue) well performed.

Motor system — Normal resistance to passive movement; no flaccidity[51] or spasticity.[52] Coordination normal in finger to nose and heel to knee tests with eyes open or closed. Rapid alternating movements of hands normal. Motor power normal. (Especially test grip, abduction of fingers, dorsiflexion of foot, flexion of leg on thigh, comparing the two sides.) No atrophy or muscle fibrillations.[53] No tremor or other involuntary movement. (The neurotic patient who is unwilling to try his utmost appears weak when he is not.)

Sensory system — No changes to pin prick or cotton wool over trunk or extremities. Position sense of fingers and toes normal. Tendo-Achilles pain sense normal. (This tendon, the heel cord, is squeezed between index finger and thumb.) Vibratory sense equal in upper and lower extremities. (If any disturbance of sensation is found, heat and cold should be tested. Should a cortical lesion be suspected, stereognosis, two point discrimination, tactile localization and numbers written in palms or elsewhere should be tested.[54] Distribution of sensory loss must be carefully determined. See the discussions of cerebral sensory loss and of sensory change in hysteria.)[55]

General considerations — No abnormalities of skin, sweating, hair

51. *Flaccid*: Weak, lax and soft.
52. *Spastic*: Muscles are in spasm and are stiff so that movements are awkward.
53. *Muscle fibrillation*: Contractions of small bundles of muscle fibers.
54. See note 27 *supra*.
55. *Sensory change in hysteria*: Hysteria is a form of neurosis; lack of an organic basis for hysterical anesthesia is indicated by the fact that loss of sensation does not correspond with anatomic pathways and the distributions of nerves. The area lacking in sensation may take varied forms.

distribution, fat distribution. (Equivocal findings have frequently led to an erroneous diagnosis in the past.)

Reflexes — (See *Technique of Eliciting the Common Reflexes.* For reference, the segment of the spinal cord mediating each reflex is given.)

Biceps	C 5, 6	Cremasteric	L 1, 2
Triceps	C 7, 8	Patellar	L 3, 4
Radial	C 5, 6	Achilles	S 1, 2
Upper abdominal	T 8-10	Plantar	L 5-S 2
Lower abdominal	T 10-12	Ankle clonus	S 1, 2

Gait — Normal; Romberg test negative. (Include regular gait and also walking tandem, *i.e.*, placing one foot directly in front of the other along a straight line. Notice especially posture and swinging of arms. The Romberg test is positive if there is increased unsteadiness in standing with feet together upon closing both eyes. This test is outstandingly positive with the position-sense loss of tabes dorsalis,[56] also known as locomotor ataxia.)

Speech — Normal spontaneously or using test phrases.

Summary of positive neurological findings.

History:
Physical:

Impression — (Etiology,[57] localization).

Disposition — (Special procedures, therapy).

Neurological Examination Supplements

Technique of Eliciting the Common Reflexes — In eliciting the reflexes it is of paramount importance to have the patient completely relaxed. A reflex consists of an automatic response of the muscle or group of muscles being tested. Frequently it will be necessary to spend a great deal of time in determining whether an inequality in the reflexes is one of significance or is one merely depending upon unequal relaxation. Too, every effort should be used to obtain a normal reflex which appears to be absent. The activity of the reflexes should be

56. *Tabes dorsalis* or *locomotor ataxia:* Tabes means any wasting of the body or a part of it. Tabes dorsalis is due to syphilis of the nervous system with degeneration of the dorsal columns of the spinal cord and of the sensory nerve trunks, with wasting. The disease is marked by crises of intense pain, incoordination, disturbances of sensation, loss of reflexes, paroxysms of functional disturbance of various organs, as the stomach, larynx, etc. The course of the disease is usually slow but progressive, and, although it may often be temporarily arrested, complete cure is very rare. The disease occurs after middle life, and is more frequent in the male sex.

57. *Etiology*: The study or theory of the causation of any disease.

recorded as follows: +indicates presence only on reinforcement (reinforcement consists of distraction, usually by having the patient contract muscles in a part of the body *not* being tested); ++covers the normal limits, which are quite variable; +++indicates definite exaggeration; ++++indicates extreme exaggeration accompanied by clonus.[58]

The biceps reflex[59] is obtained by the examiner's placing his forefinger upon the relaxed biceps tendon and striking it with the reflex hammer. The patient's forearm is flexed to a right angle when the test is made.

The triceps reflex[60] is obtained by tapping with the reflex hammer upon the tendon near its insertion, the forearm being flexed to a right angle. It is important that the muscle itself not be tapped, since response to direct stimulation has a different interpretation.

The abdominal reflexes are elicited by stroking the relaxed abdomen briskly with a slightly sharp instrument. In patients with excessively relaxed abdominal walls absence of these is not significant. However, consistent inequality of response on the two sides is quite significant if there is no operative scar on the less active side.

The cremasteric reflex consists of contraction of the cremasteric muscle on stroking the inside of the thigh with resulting elevation of

58. *Clonus*: Spasm in which rigidity and relaxation alternate in rapid succession. Courts in many states hold that a physician who examines to testify rather than to treat, can only base his opinion and findings on objective findings excluding subjective symptoms and history related by the patient. It therefore becomes a challenge for the neurologist to see how much of his data can be objectively determined or verified. See Pollock, *Examination of Motor and Sensory Function as Related to Opinion Evidence*, 1 CLINICS 1424 (1943). It should be remembered that responses are involuntary and objective.

Another interesting problem is the right of plaintiff's counsel to have a physician demonstrate to the jury subjective symptoms, such as complaints of pain when various maneuvers are carried out. The better view is that this involves objectionable self-serving, prejudicial conduct and that such a jury demonstration of subjective symptoms such as pain should not be allowed. See, *e.g.*, Lampa v. Hakola, 152 Ore. 626, 55 P.2d 13 (1936). There is actually no want of relevancy, but the courts feel that the risks of malingering and lack of jury competency to appraise trustworthiness of the demonstration make it desirable to exclude this species of evidence. See Notes, 103 A.L.R. 1355 (1936); 34 KY. L.J. 309 (1946).

In Shell Petroleum Corp. v. Perrin, 179 Okla. 142, 64 P.2d 309 (1936), the court held there was no error in permitting the mother of a small girl, in an action for injury to her eye, to remove the child's glass eye before the jury. In Wilson & Co. v. Campbell, 197 Okla. 323, 157 P.2d 465 (1945), the court held that the trial judge in his discretion properly allowed plaintiff to demonstrate the numbness of his leg by plunging a pin into it.

59. *Biceps brachii muscle*: The large muscle at the front of the upper arm: its action is to flex elbow and shoulder and to supinate the forearm, *i.e.*, turn the arm so that the palm faces upward.

60. *Triceps muscle*: The triceps brachii muscle is the triangular muscle at the back of the upper arm; it extends the forearm, assists in drawing the humerus (bone of the upper arm) backward and toward the body and supports the under part of the shoulder joint.

the testis. In males, if the abdominal reflexes are absent, or if there is any question of inequality, these should always be elicited. The scrotal reflex is much slower and should not be confused. The pyramidal tract must remain intact for the abdominal and cremasteric reflexes to be present.

The knee jerk can be elicited in the sitting position with the legs swinging free, or in the supine position with the examiner supporting the relaxed lower extremities by placing his forearm beneath the knees.

The ankle jerk is usually elicited quite easily with the patient sitting, allowing the legs to hang free. The foot is held so as to put slight tension on the Achilles tendon which is tapped with the percussion hammer. If the patient is supine, the position of choice is one with moderate flexion of the knee and flexion and external rotation of the hip. For comparison of the two sides it is well to have the patient prone, with the ankles well over the end of the examining table, or kneeling upon something soft, again leaving the ankles free. Many patients contract the anterior tibial muscle when an attempt is made to elicit the ankle jerk. This can usually be overcome by having the patient lightly press the plantar surface of the toes against the examiner's hand.

The Babinski sign is usually best elicited by stroking the lateral part of the plantar surface of the foot with an instrument such as a straightened paper clip. Slow, tonic dorsiflexion of the great toe constitutes a positive sign and is usually indicated "▲". This is an indication of involvement of the pyramidal tract.

The flexion reflex (sometimes called the defense reflex or "mass" reflex) is mediated by the portion of the spinal cord (or brain stem below the midbrain) which is severely or completely isolated as a result of injury or disease in the superior portion of the nervous system. The afferent stimulus causing this flexion or withdrawal of the lower extremity must reach the isolated portion of the cord. The threshold is variable, and almost any type of stimulus may produce this reflex. In some instances contact with the sheet is sufficient; usually it is best elicited by flexing the toes markedly.

Ankle clonus is elicited by suddenly and repeatedly dorsiflexing the foot, the knee being kept in partial flexion. Care must be taken that the patient is not contracting the anterior tibial muscle, for this inhibits clonus and may even make it impossible to elicit the ankle jerk. *Patellar* clonus is elicited by suddenly tensing the quadriceps muscle by pushing downward on the patella, which is held between the

thumb and forefinger. Similarly, *wrist* clonus is elicited by suddenly dorsiflexing the hand. This is rarely present.

The Hoffman sign is elicited by quickly extending the patient's index or middle finger with the hand held in a relaxed position. Usually the examiner places his index finger beneath the patient's middle finger and then presses it downward with his thumb. As his thumbnail suddenly releases the patient's fingernail, sudden extension occurs in the middle finger. This sudden extension of the fingernail puts the flexor tendon under stretch. Flexion of the terminal phalanx of the thumb constitutes a positive sign. This sign has the significance of a pathologically increased tendon reflex. Sometimes the sign is apparent only when the wrist is dorsiflexed. It is frequently present at one examination and absent at another. Occasionally the sign is present in psychoneurosis, presumably without organic nervous disease.

Muscle tone

Alterations in *involuntary* muscle contraction can frequently be observed by palpating muscles, by observing the contour of corresponding muscle groups on the two sides, or by determining the resistance to passive motion. By holding the wrists of the patient and shaking the relaxed hands about, one can demonstrate slight differences in the degree of muscle relaxation in the upper extremities. In the lower extremities it is useful for the examiner to flex the patient's relaxed lower extremities suddenly by quickly raising his forearm which has been placed beneath both knees. In the more spastic extremity the heel will be raised from the examining table while the other more flaccid one will flex so readily that the heel only slides along the table.

The cogwheel phenomenon consists of an intermittent resistance to passive motion and represents a latent tremor. In parkinsonism it can frequently be elicited to wrist movements or upon rotation of the forearm even when it is not observed in movements of the elbow.

Increase of tone is often visible in the fixed expression of the face or the loss of automatic arm swinging in walking.

Cerebellar signs

Nystagmus (see third cranial nerve) is described as to amplitude, frequency of oscillations, direction of gaze required to elicit it, and the direction of the rapid component. Sustained horizontal nystagmus and vertical nystagmus, even though unsustained, are always pathological. Differentiation must be made from the searching movements which occur in some cases of blindness.

Dyssynergia (or asynergia) consists of a jerkiness or want of synchronism at the different joints during a coordinated movement, so that the patient "decomposes" a complex movement into its separate elements which are performed successively instead of simultaneously. Thus in the heel to knee test, rather than simultaneously flexing the hip and knee, the cerebellar patient will flex first the hip and then the knee.

The inability to estimate the range of rapid voluntary movements with the resulting inability to arrest them at a given point is termed *dysmetria.* The overshooting of the mark in cerebellar disease is termed *hypermetria.*

Dysdiadokokinesis (or *adiadokokinesis*) means a diminution or loss of the ability to execute in rapid succession a series of movements such as pronation and supination of the forearm or flexion and extension of the fingers.

Intention tremor is variable in amplitude and occurs only on voluntary movement, particularly at the end of a movement when the postural mechanism is especially called into activity. It can be elicited by having the patient touch his nose or take something from the examiner's hand.

Past-pointing may occur with diseases affecting either the cerebellum or the vestibular mechanism (semicircular canal of the inner ear). In unilateral cerebellar disease the past-pointing is limited to the ipsilateral extremity and is said by some to vary in direction with the portion of the cerebellum involved, whereas others state that the past-pointing is always outward. It is not commonly observed except in acute conditions. In past-pointing of vestibular origin the direction of the past-pointing varies with the direction of the nystagmus and with the position of the head. Past-pointing is most easily elicited by having the patient bring his extended forefinger up from his body or from the bed to touch a rod or string held horizontally. First this is done with the eyes open, then with them closed. In normal individuals there will not be more than a few centimeters deviation.

Tests of hearing

The Weber test is performed by placing a tuning fork in the center of the forehead and questioning the patient as to whether the sound seems to be in the middle of his head or in one ear. The examiner must first determine that the fork so placed gives an audible vibration. In middle ear disease the sound is referred to the affected side, in nerve deafness to the unaffected side.

The Rinne test is performed by having the patient compare the intensity of sound when the handle of the tuning fork is held upon the mastoid process with that occurring when the prongs are held at the external meatus. Normally the latter is more intense and is termed a positive Rinne test. It is probably less confusing to record whether air conduction or bone conduction is greater.

Muscle fibrillations

Muscle fibrillations occur commonly in diseases of the nervous system, being due usually to pathological involvement of the corresponding anterior horn cells or, less frequently, to involvement of the motor roots or nerves. Fibrillations occurring in health may be limited to small areas or may be very diffuse. They are much coarser than those seen with disease processes and are never accompanied by atrophy as in disease. In muscle fibrillations in disease one observes characteristically many tiny flickering movements of the skin as tiny muscle bundles contract at random. At times these are much coarser than at others, but never does more than a small part of a muscle contract at one time in pathological fibrillation, and there is almost never perceptible movement at a joint. Muscle fibrillations are more active following motor activity. In the tongue they are more difficult to determine than elsewhere because of the tremor so frequently present. The absolute irregularity of the contractions, first transverse, again longitudinal, together with atrophy which is a usual accompaniment, makes distinction from the undulating tremor possible.

Technique for Making a Lumbar Puncture

The patient is placed on his side at the edge of the bed or examining table with his knees drawn up as high as possible and with his head flexed and supported so that the neck is not flexed laterally. The plane of the back is adjusted to as nearly a vertical position as possible. Good position almost eliminates the possibility of later difficulty. A liberal field is prepared with appropriate antiseptics. Sterile gloves are worn after the hands have been scrubbed. A sterile towel is placed beneath the patient and another is placed over the crest of the ilium, which can then be palpated. The interspace level with the crest is between L-3 and L-4 and is the point of choice for the puncture. However, the interspace above or below is, as a rule, equally satisfactory. Procaine hydrochloride, one per cent solution, is injected in the skin and beneath in the direction the puncture is to be made whether in adults or children since it assures better cooperation. The lumbar puncture needle may next be taken, stylet in place, and directed perpendicular to the plane of the back, or slightly upward toward the head. Usually at a depth of five centimeters one can feel the click and give as the needle

enters the subarachnoid space. If fluid does not flow upon removing the stylet, sometimes turning the needle will free the opening which is blocked by a nerve root. Should the patient struggle extremely, withdraw the needle at once rather than risk its being broken off. The pressure must always be measured with a water manometer and only after relaxation of the flexion of neck and thighs. No other method of determining pressure is at all accurate. If not contraindicated, it will be desirable to perform the Queckenstedt test. After completing the manometric studies and collecting the desired amount of fluid, withdraw the needle without replacing the stylet, which may have become contaminated.[61]

The Queckenstedt Test for Spinal Subarachnoid Block

The Queckenstedt test is performed as follows: A number 18 lumbar puncture needle is inserted in the usual manner and the manometer is attached. Sufficient time is allowed for the patient to become completely relaxed so that the pressure reaches the true basic level. Normally free respiratory excursions are noted in the manometer. Both jugular veins are compressed simultaneously. Normally there occurs over a period of about ten seconds a rise of pressure of a few hundred millimeters of water with a drop on release to a level near the initial level in the same length of time. The height reached depends upon the duration and degree of compression and is not of clinical importance unless very limited.

If there is a rise in pressure of only a centimeter or so, a complete block is said to exist. When the pressure rises and falls very slowly, or if there is considerable delay before the pressure rises after compression or falls after release, or if the pressure rises jerkily rather than smoothly, a partial block is suspected. One must be sure that the assistant is properly compressing the veins and that the needle is in the subarachnoid space, unobstructed by a nerve trunk. It is advisable sometimes to turn the needle or to withdraw and replace it. In case a block is suspected, one can ascertain whether or not the manometer is freely connected with the subarachnoid space by compressing the abdomen with the hand. This causes a damming back of blood in the

61. *Lumbar puncture*: Some courts have refused, under statutes providing for enforced medical examinations, to order submission to lumbar puncture in aid of diagnosis, apparently on the theory that tests which involve danger should not be made compulsory. Texas Employers Ins. Ass'n v. Arnold, 105 S.W.2d 686 (Tex. Civ. App. 1937). But does this not overlook the fact that lumbar puncture is done regularly by internes and residents on thousands of patients each year with ready permission of the subjects; that the examination is a routine, well-established procedure and involves negligible risks of any injurious reaction beyond possibly a transient headache? By way of contrast, see Cardinal v. University of Rochester, 188 Misc. 823, 71 N.Y.S.2d 614 (Sup. Ct. 1946) (motion for order requiring plaintiff to submit to bone marrow biopsy by puncture allowed). Various other medico-legal aspects of medical examinations are discussed elsewhere in this paper.

vessels of the spinal canal, thus raising the pressure. In the normal individual the spinal subarachnoid space communicates with the intracranial subarachnoid space and the rise in pressure on compressing the abdomen is moderate (usually 50 to 100 millimeters) because the fluid can escape upward. When a block exists there is marked exaggeration of response to abdominal compression (frequently 600 millimeters) because the fluid is trapped below the block.

The Queckenstedt test is contraindicated in cases of increased intracranial pressure or of intracranial bleeding because of the danger attendant upon further increasing the tension. Otherwise, it is used routinely.

Other Signs and Tests

The Beevor sign is elicited by having the supine patient raise his head off the pillow or attempt to sit up, thus contracting the abdominal muscles. The sign is positive if the umbilicus moves upward, indicating paralysis of the lower abdominal muscles without involvement of the upper ones. This signifies a lesion near the tenth thoracic segment of the spinal cord.

The Lasègue sign is elicited by flexing the thigh to a right angle with the trunk and extending the leg until slight discomfort occurs. If, in this position, dorsiflexion of the foot causes pain along the course of the sciatic nerve, the sign is positive. This latter maneuver puts the sciatic nerve under more tension without increasing the pull on the hamstring muscles. This sign indicates inflammation or irritation of the sciatic nerve or of its roots and is often termed the *sciatic nerve-stretching test.*

The jugular compression test is performed by compressing simultaneously both jugular veins, thus gradually increasing the cerebrospinal fluid pressure from the head downward. Patients with obstructive lesions of the spinal cord or cauda equina may have pain referred to the area in which it has previously occurred spontaneously. To produce a positive reaction, the lesion need not block the subarachnoid space, as is shown in disc rupture. This is of similar but greater significance in patients with such lesions than the pain experienced upon coughing or sneezing, for in the latter instances spinal movements so produced may cause pain from the sudden change in the position of either a nerve or a ligament. Straining (as at stool) raises both the pressure within the cranium (as does jugular vein compression) and the pressure within the spinal canal. Either of these pressure changes could result in pain.

The Macewen sign is said to be positive when there is a tympanitic note to percussion of the skull. When the cranial sutures are separated,

percussion with the finger produces a hollow, discordant sound which has been described as a "cracked pot sound." The skulls of small children, when tapped with a finger, often give forth a musical note which is difficult to interpret. A definite grating sound, which may result from a spread suture line, is most indicative of increased intracranial pressure.

Clinical Syndromes

A syndrome is a group of clinical symptoms and signs which, occurring together, indicate the presence of some general or even of some quite specific type of pathology. In neurological diagnosis a syndrome may be that of a particular *part* of the nervous system or it may be relatively specific for a particular kind of disease. Surgical and medical diagnosis in the field of neurology offers a tremendously interesting field to those trained for critical analysis. Some of the more characteristic clinical syndromes can be summarized. They are often identified by the names of the physicians who first described the syndromes.

Acute hemiplegia consists usually of the loss of motor power in the arm, the leg, and in the corner of the mouth on one (and the *same*) side of the body. The upper facial muscles usually recover their function, if lost at all, after a few hours or days because both sides of the brain activate the nerves to both sides of the upper face. On the involved side the tendon reflexes are usually lost during the early period, as are also the abdominal and plantar reflexes. Sensation is usually intact, but may be affected (see cortical sensation). Cortical sensation is rarely involved without definite motor impairment.

Chronic hemiplegia differs in that the involved extremities which were flaccid with absent tendon reflexes during the acute stage are now spastic with predominantly a flexed position of the upper extremity and an extended position of the lower extremity. The homolateral abdominal reflexes remain absent, but the plantar response becomes one of dorsiflexion rather than flexion of the big toe, and often of all the toes (a positive Babinski sign). Some motor power may have returned by this time, more usually in the lower extremity and in its weight-bearing muscles. Hemiplegia usually results from blockage of a deep cerebral artery in one hemisphere, but may result from cerebral hemorrhage, brain tumor or violent injury.

A total unilateral cerebral lesion can rarely be survived if caused by head injury or cerebral hemorrhage. It is usually the result of a deep arterial obstruction. The fibers from cells of the entire cerebral hemisphere converge in the basilar region (in the internal capsule) before passing to the brain stem and spinal cord. Here a relatively small amount of brain tissue may be deprived of oxygen as a result

of the blocking of a small artery by a blood clot, and yet all the important fibers from that cerebral hemisphere have been interrupted. The neurological deficit consists of *paralysis* of the lower face, arm and leg, loss of *cortical sensation,* and loss of the *visual field* or ability to see on the corresponding side of the fixation point. Such a massive lesion will impair intellect, but not hearing, smelling or tasting in any significant way, although the loss of mental ability often makes testing impossible. If the left (almost always *dominant*) hemisphere is affected, with resulting right hemiplegia, the patient will lose his ability to speak and to understand the spoken or written word (global aphasia).[62]

The crossed hemiplegia is interesting in that it is emphasized in medical school to the extent that many general physicians expect the usual hemiplegic patient to have the extremities paralyzed on one side and the face on the opposite side. This is a rare occurrence, resulting from lesions of one side of the brain stem (midbrain, pons or medulla). The reason for the crossed relationship is that the cranial nerve cells or fibers are involved along with the motor tract, which latter will *cross* lower down to motivate the extremities on the side opposite.

Bell's palsy should be mentioned to emphasize that it is not a "stroke." In young and old, especially in the "flu" months, an inflammation, probably of virus origin, affects the facial nerve (motor nerve to the face, N. VII). The paralysis comes on rapidly, affecting forehead, eyelids and mouth on one side without impairing sensation. The facial nerve, which passes through a long channel within the temporal bone, is paralyzed by its swelling within a closed space (bony canal) while another nerve, not surrounded by bone, might suffer only minor disturbances. Facial nerve (motor) paralysis resulting from basal skull fracture, tumor or other causes is accompanied usually by other neurological findings and should not be called "Bell's palsy." Recovery is the rule in the facial paralysis resulting from virus inflammation.[63]

The syndrome of decerebrate rigidity occurs either in massive lesions affecting both cerebral hemispheres or in conditions affecting the upper part of the brain stem, thus separating the cerebral hemispheres

62. In determining whether a cerebral lesion is due to traumatic injury or to an unrelated, independent cerebral vascular accident, one takes into account such factors as (1) the adequacy of the trauma to produce such an effect; (2) the age of the victim, since young persons are only rarely subject to cerebral vascular accidents; elderly and aged persons are more likely to suffer them ("strokes"); and (3) the time interval following trauma before appearance of vascular phenomena; the longer the time interval the less likely is causal connection. A review of recent cases indicates that courts and commissions take a skeptical view toward attempts to connect apparent "strokes" with a traumatic causation.

63. *Bell's palsy*: For collection of cases, see Note 16 A.L.R.2d 3, § 61 (1951).

from the lower brain stem and spinal cord. Obviously, this syndrome indicates a critical degree of involvement of the central nervous system. It is most frequently produced by violent injury, but may be the result of massive hemorrhage, thrombosis or tumor.

A period of relaxation (flaccidity) of the four extremities usually precedes this type of rigidity for several hours after the catastrophe has occurred. Decerebrate rigidity differs from the rigidity of chronic double hemiplegia (a right and left hemiplegia, usually occurring in succession) chiefly in that the arms are usually held stiffly extended in the former. In addition, voluntary movements of a crude type are often present. Painful stimulation of the decerebrate patient may cause many different patterns of contraction of muscles with *rigidity* a prominent feature of each position assumed. Few patients survive a pronounced syndrome of decerebrate rigidity. The rigidity occurring in hysterical attacks of a severe nature is more bizarre and is unaccompanied by the serious changes in vital functions (temperature, pulse, respiration) occurring in the decerebrate state.

The Parkinsonian syndrome is characterized by muscle rigidity with slow rhythmic tremor, fixity of expression, monotony of voice and slowness of movement. Occurring in the aged, it is known as paralysis agitans or shaking palsy. It is often more severe in young people following certain virus infections of the brain and is then called post-encephalitic parkinsonism.[64]

Horner's syndrome results from division of the sympathetic nerve supply to the head. It results homolaterally from involvement of the medulla oblongata, of the cervical spinal cord, or of the eighth cervical and first thoracic roots as they send fibers to the sympathetic chain. Involvement of the sympathetic nerves as they ascend to the head is most common. This syndrome consists of a drooping of the eyelid

64. *Parkinson's syndrome*: Muscular rigidity, immobile facies, tremor, which tends to disappear on volitional movement, abolition of associated and automatic movements, salivation and cramps, due to lesion of the *globus pallidus* (part of the basal nuclei). This syndrome (or collection of symptoms) is characteristic of the disease known as *paralysis agitans* (Parkinson's disease), and is seen as a frequent sequel of the virus infection called *lethargic encephalitis*. The disease is not now considered to be due to trauma, though the claim is sometimes made in personal injury cases. See, *e.g.*, Kern v. Pullen, 138 Ore. 222, 6 P.2d 224 (1931). Claim of aggravation of existing Parkinson's disease of trauma also comes up occasionally. See, *e.g.*, Wood Preserving Corp. v. McManigal, 39 F. Supp. 177 (W.D. Ky. 1947). There is still some dispute as to whether this is possible, but we think very strict criteria of proof would need be satisfied. Theoretically, destruction of tissue in the area of the *globus pallidus* in the brain consequent to trauma might produce Parkinson-like symptoms. Here, again, great skepticism must be shown in scrutinizing a particular case, for one should remember that this area of the brain is far removed from the surface. The great probability, and therefore the initial presumption, would be that the symptomatology was due to Parkinson's disease pre-existing the disease or arising coincidentally without causal relation.

(ptosis) of partial degree, recession of the eyeball within the orbit, contraction of the pupil in comparison with its mate and loss of sweating (anhidrosis) of that side of the face. It most usually results from a tumor arising from the upper part of the lung or pleura.

The syndrome of the cerebellar angle usually results from the growth of a benign tumor (most often an acoustic neurinoma) from the eighth cranial nerve as it leaves the brain stem to enter the petrous pyramid of the temporal bone in which the inner ear is lodged. The important signs are on the same side as the tumor. The usual signs are deafness, loss of labyrinthine (equilibratory) function, numbness and weakness of the face (due to involvement of neighboring cranial nerves) and incoordination due to pressure upon the cerebellum or its pathways in the brain stem. Finally the generalized increase in intracranial pressure produces more critical changes in the patient's condition.

Medico-Legal Aspects of Neurological Examinations

We have already had occasion to allude, in some degree, to the legal limitations on medical examinations which the adversary would like to have performed by his own doctors, or by a court-appointed physician.[65] The party who seeks a court order to require the adversary to submit to medical examination must show the relevancy and likely value of the proposed procedure. He should make a prima facie showing that the examination would not involve any undue invasion of plaintiff's rights of personality by subjecting him to a dangerous or highly painful type of examination or operation.[66] It would seem to

65. See note 61 *supra.*

66. It is proper for a trial court to refuse to order a second examination where defendant, the moving party, fails to show any need for it. Bailey v. Bush, 279 App. Div. 833, 109 N.Y.S.2d 580 (1952). This is to be contrasted with the judicial attitude where movent shows that the true nature and extent of the injuries can be determined only by examination. Alabama G.S. Ry. v. Hill, 90 Ala. 71, 8 So. 90 (1890) (order for vaginal examination granted despite delicate feelings of plaintiff).

If the examination would not provide crucial evidence likely to be conclusive of the issue, many courts are reluctant to order it. Riss & Co. v. Galloway, 108 Colo. 93, 114 P.2d 550 (1941); Louisiana & A.R. Co. v. Woodson, 127 Ark. 323, 192 S.W. 174 (1917); Beuschel v. Manowitz, 241 App. Div. 888, 272 N.Y. Supp. 165 (1934), *leave to appeal denied,* 265 N.Y. 509, 193 N.E. 295 (1934). But this view seems to be overly stringent; it should be enough that the examination is medically indicated as a proper means of discovering substantial facts.

It is not an abuse of discretion to consider an examination dangerous where the testimony on that score is conflicting. Carrig v. Oakes, 259 App. Div. 138, 18 N.Y.S.2d 917 (1940), *leave to appeal denied,* 259 App. Div. 798, 18 N.Y.S.2d 918 (1940) (plaintiff's affidavit stated that cystoscopic examination could cause death while defendant's physician made an affidavit that he had never known of a case of harmful, serious or fatal result). *Accord,* Cincinnati, N.O. & T.P. Ry. v. Nolan, 161 Ky. 205, 170 S.W. 650 (1914); O'Brien v. LaCrosse, 99 Wis. 421, 75 N.W. 81 (1898). Furthermore, where the court has not had evidence put before it as to lack of danger, and cannot take judicial notice that a medical

us desirable, in the social interest, to require submission to necessary examinations of a sort which are proposed and accepted routinely by patients in hospitals and clinics incident to diagnosis or treatment.[67]

Many of the acute and chronic diseases of the nervous system have no relation to traumatic injury. By taking depositions of the claimant and of his physicians, and of past social contacts and fellow employees, it may be readily possible to show that the individual was suffering from a well established disease long prior to the date of the accident sought to be incriminated. In any event, counsel should be able to obtain from plaintiff a full account of his complaints as a basis for further investigating their probable origin or authenticity. If the plaintiff claims aggravation of a pre-existing disease, rather than primary causation, lawyers for both parties will need to study the typical life history of that disease to learn how rapidly it progresses and what its usual manifestations are when not affected by trauma. It is by no means accepted that every disease can be aggravated by trauma. On the other hand, the plaintiff should not overlook the fact that a person who is debilitated and weakened by a pre-existing disease, and who has his resistance lowered thereby, may suffer a more extensive disability than a person in good health would sustain as a result of the same traumatic stimulus. Under the law of torts, "the wrong-doer takes his victim as he finds him."[68] The plaintiff's lawyer may be able to substantiate causal connection between trauma and subsequent disability or death by relying upon the special vulnerability and depleted reserves of the victim, when it is scientifically improbable that a pre-existing disease has been aggravated.

Adequate probing of these factors requires appropriate diagnostic studies. Since disease of any sort is capable of producing only a

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test is safe, it will not order the examination. Grill v. Mathieson Alkali Works, 243 App. Div. 853, 278 N.Y. Supp. 775 (1935).

If the proposed examination would produce serious pain this circumstance alone, or in conjunction with other factors is ground for refusing an examination order. Kokomo M. and W. Traction Co. v. Walsh, 58 Ind. App. 182, 108 N.E. 19 (1915) (physical examination requiring rupture of hymen refused because serious pain results). But transient or mild discomfort will not cause denial of an indicated examination. Heilig v. Harrisburg Ry., 17 Pa. D. & C. 509 (1932) (eye examination ordered as it appeared the three drops of holocain to be used would produce only a slight sting, such as water).

67. This was a general philosophy followed by the armed services during the last war in determining whether or not refusal of an enlisted man to submit to surgery designed to overcome a disability was reasonable or arbitrary. We think that highly dangerous operations, of speculative value, should not be forced on a man by indirect coercion, such as forfeiture of benefits or reduction of damages. Where the procedure is treatment which would be applied by surgeons generally, and accepted by patients as a class, in cases involving no medico-legal problem, we think it should be considered unreasonable for the claimant to decline the medical attention.

68. Purcell v. St. Paul City Ry., 48 Minn. 134, 50 N.W. 1034 (1892); Spade v. Lynn & Boston R.R., 172 Mass. 488, 52 N.E. 749 (1899). These are the "stem" authorities in American law. For additional cases see the Damages topic in the Decennial Digests, key numbers 33, 95, 132(3), 168 and 208(2).

limited number of *signs* and only a limited number of *symptoms,* and as particular constellations of signs and symptoms may be due to several alternative causes, it is necessary to carry out a careful *differential diagnosis.* By this we mean that the examining physician must be conscious of the competent producing causes of the signs and symptoms found. In certain conditions resort to the medical literature may be very informative. He must then systematically eliminate one alternative possible cause after another by appropriate tests or special examinations until the one best supported explanation or diagnosis remains. This process is called the making of a *differential diagnosis.* Various books which deal with differential diagnosis take up signs and symptoms alphabetically and indicate the various diseases or conditions which may produce them.[69] However high the ideal of the author, such reference books are of little practical value except in particular instances. The lawyer who is undertaking cross-examination as to the adequacy of a medical examination or diagnosis, should not overlook the value of interrogating the supposed expert as to the meaning of "differential diagnosis," as to what signs and symptoms were found and as to what other diseases or conditions could produce those same signs and symptoms. Finally, taking each of those conditions, one at a time, he might ask what the physician did by way of special tests or examinations to rule out each alternative possible cause of the patient's illness. This is one of the quickest and fairest ways to expose a superficial examination or one which is not definite enough to warrant the granting of substantial damages.

In our judgment, when a neurosurgeon has treated an alleged injury to the nervous system, his testimony should be heard or accounted for and his findings should be entitled to respectful audience in evaluating the presence, location and degree of organic lesions. Our experience has been that information from cooperating experts sometimes is needed in evaluation of disability, as, for instance, from the original attending physician, the neurologist, the psychiatrist, the clinical psychologist, and the electroencephalographer (brain wave expert). All of these are auxiliary sources of information. In well studied cases the various findings under this "multi-dimensional" approach should fit together, providing cross-corroboration for the diagnosis and prognosis. Caution and skepticism are indicated where there is a head-on conflict between findings of relevant specialists. However, it must always be kept in mind that in some fields of medical science, usually newly developing frontiers, divergent opinions exist amongst well-informed specialists. Even minor disparities of opinion may appear greatly magnified by the type of interrogation made by counsel. In our

69. FRENCH, AN INDEX TO DIFFERENT DIAGNOSIS OF MAIN SYMPTOMS BY VARIOUS WRITERS (4th ed. 1948) (latest edition now at press); MACBRYDE, SIGNS AND SYMPTOMS (2d ed. 1952).

judgment, no medical examination of a case involving disease or injury of the nervous system can be considered complete unless a systematic neurological examination has been carried out by a competent examiner and the neurological findings (positive and negative) have been carefully noted. We turn now to that subject.

THE NEUROLOGICAL FINDINGS IN SEVERAL COMMON CONDITIONS

Head Injury

Head injury, often termed craniocerebral injury in the neurosurgical literature, is one of the most frequently encountered medicolegal problems. We find that injury to the skull (fracture) is decidedly more frequent in fatal injuries than in less serious injuries. However, no patient ever died from a skull fracture *per se*. A patient with a fractured skull may die from loss of blood resulting from scalp hemorrhage. Death more frequently results from the tearing, bruising and swelling of important parts of the brain. An arterial hemorrhage (usually from the middle meningeal artery) may cause death from increased intracranial pressure when the initial injury seems trivial and the patient has once recovered consciousness. Continued bleeding or late increase in the size of a pocket of blood due to the increased osmotic pressure[70] of the decomposing hemoglobin[71] may bring a fatal outcome if operation is not instituted sufficiently early (in extradural, subdural and subcortical hematoma). The patient who cannot cough, swallow or spit may often die from lung infection. Obstruction to the respiratory passages is so often an immediate threat to life that tracheotomy[72] is being used in an increasing number of cases. This procedure provides a breathing passageway through the tracheal wall and tissues of the neck. It also provides an opening through which a catheter[73] can be introduced within the bronchial passages[74] to suck away obstructing fluids. Then, too, associated injuries play no small part in death from craniocerebral injuries.

Surgical exploration under local anesthesia results in little addi-

70. *Osmotic pressure*: Osmosis comes from the Greek, meaning impulsion. It signifies the passage of pure solvent from the lesser to the greater concentration when two solutions are separated by a membrane which selectively prevents the passage of solute molecules but is permeable to the solvent. The membrane which permits cerebrospinal fluid to pass into the denser contents of the clot causes the latter to increase in size, raising intracranial pressure as any space filling lesion inside the skull will do.

71. *Hemoglobin*: The oxygen-carrying red pigment of the red blood corpuscles.

72. *Tracheotomy*: The formation of an artificial opening into the trachea, *i.e.*, windpipe; the operation of cutting into the trachea.

73. *Catheter*: A tubular surgical instrument for withdrawing fluids from a cavity of the body.

74. *Bronchial passages*: The windpipe (trachea) divides into a right and left bronchus; these are round conduits through which air passes into and out of the lungs during the course of respiration.

tional mortality in head injuries, provided that it is properly performed. The operation is dramatically life-saving when a surgical lesion (a hematoma) is found. Exploration does little to lessen the possibility of a favorable outcome (under adequate conservative treatment) when no benefit results from operation. The decompression operation (subtemporal decompression) has been abandoned in patients with cerebral injury unless the decompression can be made directly over the area of severe injury or hemorrhage. Spinal puncture and puncture of the cerebral ventricles may be of diagnostic or of therapeutic value.

The judicious use of penicillin, sulfadiazine and other drugs may save the life of the patient who has a contaminated wound, either from surface injury or from a "gateway" resulting from fracture into an infected sinus or mastoid. Nevertheless, these drugs must never be used indiscriminately or the harm may outweigh the good.

When the scalp has been lacerated, surgical repair is necessary. The wound must be examined for underlying fractures, for foreign bodies and for the vitality of tissue. Closure is much safer if the interval following injury is less than 24 hours. However, scalp wounds are rarely drained in the manner frequently used in other parts of the body.

Depressed fractures, if compound fractures, should be repaired as soon as the condition of the patient justifies it. If no laceration overlies a depressed fracture, repair is less urgent, but should be done at the earliest reasonable opportunity in order to minimize permanent brain damage. These seemingly simple reparative procedures often tax the judgment of the experienced neurological surgeon. How far should he probe for a bullet or other foreign body? Many questions enter his mind during the operative procedure and may be altered by the findings or complications at successive stages. If the operation is performed with other than the optimal neurosurgical technique, hemorrhage and other complications may pyramid rapidly. However, one must not criticize too readily, for even when properly performed a well-indicated surgical procedure can occasionally become seriously complicated in a matter of seconds.

The immediate causes of death in head injury have been described. The difficulties of judgment, even for able neurosurgeons, are many. The patient without fracture may die in minutes or days without recovering consciousness. The patient with fracture may get up after being struck down by a baseball, behave in a perfectly natural manner for several hours or even for one or two days, go to bed with a headache — and never again wake up.

Extradural hemorrhage

An extradural hemorrhage from the middle meningeal artery[75] is the most immediately dramatic condition known to neurological surgery. A patient who would otherwise only have minutes to live may, during operation in which the clot is removed, recover consciousness and proceed to good health. Again, a rather infrequent surgical lesion is emphasized because of its great importance. More chronic conditions need not be recognized so promptly.

A patient with a massive extradural hemorrhage cannot possibly be kept awake. Nevertheless, the story persists that the injured patient, if kept awake, will not die. The truth lies in the fact that the patient who has a progressive arterial hemorrhage *cannot possibly be kept in a conscious state.*

An extradural hemorrhage can usually be identified far more readily than can a subdural hematoma, which usually occurs later in the course of head injury.

Hemorrhage from the middle meningeal artery rarely exists without fracture. An extradural hemorrhage underlies a fracture in 90 per cent of instances, but fractures are frequently present in this area with no extradural hemorrhage. On the side of the hemorrhage the pupil is usually dilated, but this occurs late in the course. Convulsions occur frequently and are often confined to the side opposite to that of the hemorrhage. When weakness or paralysis is present, it is usually on the side of the body opposite to the side on which the brain is compressed. The pulse may be slow and the breathing is often slow and even, until death is imminent. If an arterial hemorrhage occurs intracranially in a rapidly progressive manner, the patient's blood pressure will mount rapidly from a systolic pressure of perhaps 120-150 to 180-210, or even to 240 or higher, and then will rapidly drop with a fatal termination. Slower increases in intracranial pressure produce *no* significant blood pressure changes. Marked fluctuation of blood pressure is possible without there being any intracranial bleeding. A patient who dies, presumably from increased intracranial pressure from an intracranial tumor which is known to be present, rarely shows a change in blood pressure.

The occurrence of a *lucid interval* after a craniocerebral injury is of extreme importance. This term indicates a more or less complete recovery of consciousness which is followed by a progressive loss of mental ability and consciousness. The implication is that the brain, as a whole, has not initially been severely injured, but instead a complication (extradural hemorrhage) is producing the progressive

75. *Middle meningeal artery*: It should be recalled that this artery runs forward, grooving the inner table of the skull and is susceptible to being torn by a fracture which crosses its course with resultant extradural hemorrhage or bleeding.

changes. A subdural hematoma is far more difficult to diagnose than is an extradural hemorrhage, but it is far more common.

Chronic subdural hematoma

This entity may be encountered after any type of head injury, but usually after those less critical. Skull fracture is as often absent as present. The more usual signs may include those associated with increased intracranial pressure, but these are often absent. Paralysis and convulsions occur, but are uncommon.

Usually the necessity of exploration for subdural hematoma occurs when a patient who has been doing fairly well does poorly, with only progressive cerebral involvement to account for it. Positive neurological findings may be present, but cannot be depended upon. The spinal fluid pressure is often normal. A significant, but unaccountable, relapse in the course of convalescence from a head injury often makes exploration for subdural hematoma a necessity. The careful opening of the cranium by an able neurological surgeon may save the patient's life if a subdural hematoma is present and will not significantly jeopardize his life if the exploration be negative.

Summary — Extensive brain laceration or contusion can rarely be benefited by surgery. With rare exceptions, subtemporal decompression is an inadvisable procedure. The accepted exploration for the surgical type of hemorrhage by multiple trephine openings,[76] utilizing local anesthesia, rarely affects the patient's condition in an adverse manner and may be life-saving if a surgical condition is discovered. Periodic observation by trained nurses and re-analysis of the neurological findings by the attending physician are necessary in case of an unfavorable trend.

Special Procedures in Neurological Diagnosis

The x-ray (roentgenological) examination — Whenever a serious disorder of the nervous system may possibly be present, x-rays must be made of the suspected area. In the skull or spine, fractures are usually demonstrable in carefully taken films. X-rays of poor quality are an abomination and prove little or nothing. Poor technique is too frequently blamed upon the difficulties of positioning a critically ill or obstreperous patient. Only bone and calcified areas in soft tissue are usually demonstrated in roentgenograms. Although many serious conditions involving the nervous system produce no demonstrable x-ray changes, there is always the possibility of help from this source.

A lack of positive x-ray findings in rupture of the intervertebral

76. *Trephine operation:* Removal of a circular disk of bone by a crown saw; the simple boring of an opening into the cranial cavity.

disc and certain other intraspinal conditions is the rule rather than the exception. Myelography (the use of iodized oil or other contrast media in the spinal subarachnoid space) may demonstrate a lesion when other methods fail. However, it is important to emphasize that *special techniques are only an addition to thoughtful clinical diagnosis.* No special procedures supplant the neurological examination, although many important findings decidedly alter its interpretation.

The spinal puncture (or lumbar puncture as it is often called because of the part of the spine through which the puncture is made) is a frequent procedure in neurological diagnosis. The technique has already been discussed. If properly performed and not contraindicated, it is a completely safe procedure. However, a distressing headache may occasionally follow. It is usually present only when the patient is upright, but it may recur for as long as two weeks. Spinal anesthesia is accomplished by injecting one of several anesthetic substances after a lumbar puncture has been performed in the conventional manner. Catastrophes — death or paralysis — have occurred, as they have with all types of anesthesia.[77] Death has probably resulted chiefly from improper technique, rarely from an allergic reaction.[78] Extensive paralysis has rarely resulted unless a substance of mistaken identity was injected through the spinal needle into the region of the cauda equina. Direct injury to the roots within the lower subarachnoid space cannot be attributed to lumbar puncture *per se.* Many serious conditions are *occasionally* made worse by drainage of cerebrospinal fluid. Unfortunately, these rare occurrences are often considered by the laity to *result* from spinal puncture.

Suffice it to say that in good hands spinal puncture is a safe procedure, and spinal anesthesia is as valuable an anesthetic as we have today. Spinal anesthesia is contraindicated in cases of spinal cord tumors and fracture dislocations of the vertebral column. Although it is not contraindicated in operations on ruptured discs, some neurosurgeons avoid it because they feel that spinal anesthetic agents may occasionally cause neurological involvement which can be erroneously attributed to the surgery.

Electroencephalography.— Before discussing more meddlesome procedures, it is well to discuss electroencephalography. This test is of no significant annoyance to the patient since it is accomplished merely by gluing electrodes to the intact scalp and greatly amplifying the tiny currents which result from brain activity. This test is comparable to

77. *Spinal anesthesia*: For cases involving injuries allegedly due to mode of administering anesthetic, see Note, 13 A.L.R.2d 11, §§ 5, 10, 11, 27, 30 and 34 (1950).

78. *Allergy*: A condition of unusual or exaggerated specific susceptibility to a substance which is harmless in similar amounts for the majority of members of the same species.

the electrocardiogram, but has not yet attained the diagnostic dignity or esteem which the latter enjoys in its limited range of usefulness when made and interpreted by competent specialists. The personal equation of the interpreter of an electroencephalogram is so important that, in many ways, this procedure must still be considered to be in an experimental stage.[79]

Pneumoencephalography — This special procedure is of considerable annoyance to the patient in that a severe headache of two or three days' duration results. This test is performed by exchanging 10 cc. quantities of cerebrospinal fluid for oxygen until about 100 cc. of fluid are replaced with oxygen. Thus the oxygen replaces the cerebrospinal fluid throughout the subarachnoid space and ventricular system. Roentgenograms made after the injection reveal details of brain atrophy or displacement which are often of invaluable diagnostic help. The risk to the patient is only the risk of a short period of anesthesia unless some dangerous pathology is present in either the brain or cervical spinal cord.[80] When the presence of a serious space-taking lesion is suspected, pneumoencephalography is supplanted by ventriculography which will be discussed shortly.

Trephine exploration — The trephining of small holes in the cranium where hemorrhage is suspected has become a usual and often a life-saving procedure. Injury or infection (usually brain abscess) prompts such exploration. Such a lesion is usually sought under local anesthesia with little risk to the patient. The numerous negative explorations, properly performed, constitute almost no risk. If an abscess or clot can be evacuated, a life may be saved.

Ventriculography — When the diagnosis of a space-taking lesion is imperative, pneumoencephalography (spinal oxygen injection) is often contraindicated. Direct replacement of ventricular fluid through a trephine opening in the skull is safer in such instances and makes it possible usually to determine the presence of a surgical condition. Boring holes through the skull must not be undertaken lightly. In the armed forces no trephined patient was likely to be given permission to

79. *Electroencephalography*: See Gibbs, *Medico-legal Aspects of Electroencephalography*, 24 CAN. B. REV. 359 (1946).

80. *Pneumoencephalography*: In Egelston v. Industrial Comm'n of Arizona, 52 Ariz. 276, 80 P.2d 689 (1938), it was held no error to refuse request and offer of second pneumoencephalogram where "predicated upon commission paying the bill therefor" under circumstances of controversy as to clarity and interpretation of first P.E.G., but where a number (5) of physicians claimed symptoms were in no way related to head injury or accident except indirectly.

Cole v. Town of Miami, 52 Ariz. 488, 83 P.2d 997 (1938), affirmed a decision of the industrial commission denying further compensation where claimant refused encephalograph (to rule out possibility of brain tumor), and where commission found procedure not to be so dangerous as to be unacceptable under circumstances such that case could not be conclusively established without the test.

fly again. Opening the cranium, when necessary, has become a safe surgical procedure, but it must never be done without proper indications. At one time in the past few years the skull was opened so commonly by one surgeon in good-risk patients who had no serious intracranial pathology that trephination was nicknamed the woodpecker operation. Needless operation upon these disturbed patients was not without serious complications. Nevertheless, opening of the cranium and operation upon the brain are relatively safe procedures when they are necessary.

Angiography — The injection of an organic compound with a high iodine content into the internal carotid artery has become an accepted diagnostic procedure. Roentgenograms (x-rays) are made at the time when the arterial content of contrast medium is at a maximum. The arborization of the arterial trunks is thus recorded in an accurate manner. Aneurysms or even brain tumors may be demonstrated in this way. There is very little risk to the patient from this procedure, but a greater one when a serious condition is present.

Neurosurgical operations — Cranial operations are most usually performed for conditions which take up space within the cranial cavity, so called "space-occupying" lesions. Abnormal accumulations of blood or fluid, abscesses and tumors comprise the bulk of cases. In patients with craniocerebral injuries operation is directed toward converting a contaminated wound to a clean one, removing any foreign bodies or material, and reestablishing the cranial vault as well as is practicable. Occasionally the surgical removal of old cerebral scars is indicated when intractable convulsive seizures have resulted.

Increased intracranial pressure is a very definite and important condition demanding specific measures directed toward its relief. However, increased pressure is far too frequently given as the explanation for persistent symptoms when no increase is actually present and no operative procedure is indicated.

Estimation of Permanent Damage

The legal mind is probably more frequently interested in the after-effects of head injury than in the detection of the surgical complications. Permanent damage is quite concrete when it results in a degree of paralysis. Paralysis of certain cranial nerves is not an uncommon occurrence in patients who have had basal skull fractures. Loss of the sense of smell (N. I.) is common (N. indicates cranial nerve). Unilateral blindness (N. II) is rare, but permanent double vision (N. III, IV, or VI) is relatively common. Numbness of part of one side of the face (one or more branches of N. V) is common, but not very incapacitating unless the patient makes it so. Facial paralysis (N. VII) is often

permanent with only incomplete correction possible. It is a distinct handicap to one who must meet the public. Unilateral deafness (N. VIII) is annoying, but is often less disabling than a partial lesion of the eighth cranial nerve with ringing, vertigo[81] and partial deafness. Impairment of the remaining four cranial nerves is rarely a sequel of head injury, because extensive fracture in the posterior fossa of the cranium which might involve these nerves carries an exceedingly high mortality rate.

Paralysis (or paresis) and hemianopsia[82] are more difficult to evaluate, but give tangible evidence of their presence. Many findings recorded in the neurological examination are of short duration, but nevertheless have a meaning in the estimation of later disability.

Alteration of personality, impairment of judgment and loss of intellectual ability are sequelae which are far more difficult to evaluate than are the more tangible *neurological deficits*. These features are often so prominent in a patient with psychoneurosis following a trivial injury that unless the neurologist or neurosurgeon knows the complete series of events he will be at a loss to estimate the true degree of disability. The frequent inattention of a neurotic patient may give the appearance of true loss of concentration or judgment.

Fortunately, in many instances it is possible to judge, as a neurologist, that there is true impairment of brain function (even in the absence of positive neurological findings). Unfortunately, many personality defects are attributed, injudiciously, to the presence of brain injury. This is especially apt to happen when a plaintiff who has had his feelings hurt has a skilled lawyer and one or more doctors who are not very critical in their appraisal of the case.

There are a number of facts which are quite useful in estimating true mental impairment from head injury. In any large series of head injuries the patients with skull fracture (demonstrated clearly by an able roentgenologist) have been more severely injured than those who have no demonstrable fracture. Earlier, in contrast, we have mentioned the critically injured patient who has no demonstrable skull fracture. When the patient is more than restless, roentgenograms are difficult

81. *Vertigo*: A sensation as if the external world were revolving around the patient (objective vertigo), or as if he himself were revolving in space (subjective vertigo). For collections of cases, see Notes, *Excessiveness of Damages in Action by Person Injured for Personal Injuries not Resulting in Death*, 16 A.L.R.2d 3, 192 (1951); 102 A.L.R. 1125, 1324 (1936); 46 A.L.R. 1230, 1314 (1927); *Adequacy of Damages in Action by Person Injured for Personal Injuries not Resulting in Death*, 16 A.L.R.2d 393, 410, 429 (1951); *Physical Defect, Illness, or Drowsiness of Operator of Automobile as Affecting Liability for Injury*, 138 A.L.R. 1388 (1942), 64 A.L.R. 136 (1929); *Negligence Causing Physical Injury as Proximate Cause of Subsequent Independent Injury to Same Person*, 76 A.L.R. 1285 (1932). See also Smith, *Medicolegal Facets of Epilepsy*, 31 TEXAS L. REV. 765 (1953); Kaufman and Kantrowitz, *The Case of the Sleeping Motorist*, 25 N.Y.U.L. REV. 362 (1950).

82. *Hemianopsia*: Blindness in one-half the field of vision in one or both eyes.

to make and even more difficult to interpret. Some physicians are much too willing to interpret mediocre films and to draw conclusions from them. When, during the early critical period, x-rays have been made of the head, later x-rays, made under more favorable circumstances, may show fractures which were not apparent in earlier films. *The willingness to testify when only films of inferior quality are available* can be justified only by the exigencies of a real emergency with no subsequent opportunity to improve upon the quality of the roentgenograms.

The most generally reliable indications of the degree of injury are the period of memory lapse prior to the injury (retrograde amnesia) and the period of memory loss following the injury (anterograde amnesia). The amnesic period immediately preceding the injury is usually in proportion to the post-traumatic amnesic period, but is much shorter and roughly in the ratio of seconds to minutes or hours. It is important that one consider the recovery of *relatively continuous memory* in establishing the period of post-traumatic amnesia. Often a patient, after appearing completely unconscious for a while, will appear to recover consciousness when actually he will have no memory for that period.

Absence of retrograde amnesia makes one doubt a diffuse cerebral injury of any severity. On the other hand, patients who have had severe injuries will often testify relative to incidents immediately preceding an accident which could hardly (if at all) be remembered with accuracy. In patients injured severely, the willingness to testify (after hearing the events rehearsed) may often be a symptom of the mental impairment which is present.

Psychotic periods occurring after cerebral injury are not uncommon. The prognosis in these injured people is quite favorable in contrast to the prognosis in psychoses which occur in the uninjured.

Convulsions which occur early in the course of a head injury are important especially in that they may indicate the presence of a surgical complication. Other factors are more important in indicating the probability of convulsive seizures complicating the later course of head injuries. Paralysis, even if of short duration, increases the possibility of complications such as post-traumatic convulsive seizures. The patient who has recovered satisfactorily from a severe traumatic hemiplegia may have as high as a 30 per cent probability of having convulsive seizures complicate his later life. Unfortunately, convulsions are relatively unpredictable and may first occur as long as five to ten years after a head injury. Often, convulsions, by their pattern, indicate that the irritative focus in the brain could only have followed a localized injury. A predisposition (diathesis) to convulsions, without their actual occurrence, provides a medico-legal problem which is very

difficult to evaluate.[83] Convulsions are quite serious in that they may occur at a time when they jeopardize the patient's life. Amnesia for the convulsive episode is fortunately common and probably accounts for the relative lack of fear in patients who are subjects to convulsions.

Did the patient who fell and injured his head fall as a result of a convulsion? Did the patient fall because he lost consciousness as a result of cerebral thrombosis? In either case he may well have fractured his skull. There are certain probabilities which are worthy of neurological estimation. A typical hemiplegia with no significant evidence of injury could hardly have resulted from trauma. It is important medico-legally that people often fall as a *result* of intracranial medical disease.

It is important, too, that a patient whose original injury seemed trivial not be denied medical care simply because a second injury brought out the more serious symptoms. Aggravation has been accepted legally. It matters little whether a patient was originally injured under the auspices of one insurance carrier and was disabled under the auspices of another. These little factors will equalize. The injured patient must be adequately cared for, whether or not the sequence of events is entirely clear. Certain companies protect their employees almost as much from disease as from injury, but this attitude is not general.

Some Applied Medico-Legal Aspects of Head Injury Cases

Remember that the cranium is a closed box made of bone to protect the brain and that the latter is invested in three membranes (named, from without inward, the dura mater, the arachnoid and the pia mater), which permit movement of the brain to a certain degree. If the head is suddenly brought into contact with the windshield of a car in a collision, the brain decelerates less rapidly than the skull. The resultant jostling back and forth may cause bruising (contusion) or tearing (laceration) of the brain tissues. The base of the skull contains sharp bony promontories and eminences. A blow to one part of the skull may cause the brain to be injured by its striking such bony projections though the impact was initially sustained to the opposite sur-

83. The law of damages is well settled that compensation can be recovered only for such future losses or consequences as are reasonably certain (or probable) to occur. This requirement applies to the total offer of evidence, however, and a physician's testimony that epilepsy in the future is possible is admissible since proof of possibility is a step on the road to proof of probability. Bauman v. City and County of San Francisco, 42 Cal. App.2d 144, 108 P.2d 989 (1940).

Risk of impending epilepsy below 50% is generally held to be too conjectural to be directly compensated as a distinct head of damage, yet if such a risk is scientifically calculable, it seems clear that the information is admissible as circumstantial evidence going to prove the seriousness of the present injury. Smart v. Raymond, 142 S.W.2d 100 (Mo. App. 1940); see Smith, *Medicolegal Facets of Epilepsy*, 31 Texas L. Rev. 765 (1953).

face or pole of the brain (*contrecoup* injuries). Movement of the brain backward and forward may cause tearing of the cerebral veins passing from cerebrum to the large dural venous channels causing intracranial hemorrhage.

Records of trial cases indicate prevalence of certain dangerous myths concerning head injuries. One of these is that fracture of the skull, demonstrable by x-ray, proves serious brain damage without other supporting evidence. This, of course, is false, as is the assumption that concussion of the brain, alone, is a serious and permanent injury justifying large awards of damages. Other common errors of thinking involve the assumption that a substantial head injury will almost inevitably affect the subject mentally, and very likely will produce future insanity. Actually, the incidence of traumatic psychosis in admission diagnoses of mental hospitals of this country is considerably less than one per cent.

Traumatic neurosis is one of the most vexatious of all medico-legal problems. It is erroneous to assume that traumatic neurosis usually involves permanent disability rather than temporary disability. It is equally incorrect to assume that a person suffering from traumatic neurosis today may tomorrow deteriorate into a state of traumatic psychosis (insanity). A neurosis involves only emotional conflicts resulting in symptoms as a diffuse form of expression; a psychosis involves a distortion of reality. There is no sufficient scientific evidence that neurosis is a half-way station in the development of a psychosis.

It is an interesting and important fact that head injuries seem to be self-sifting to a degree; that is to say, those who will die usually do so within a matter of hours or days or at the most weeks; furthermore, most of the complications, such as hemorrhage or infection, will occur, if at all, at an early time. The chief late complications to be thought of are traumatic epilepsy, chronic subdural hematoma (blood clot) and, rarely, cerebral abscess due to infection. Approximately fifty per cent of those who will develop traumatic epilepsy do so within twelve months of the injury though there are well documented cases in which traumatic epilepsy appeared a number of years after the head trauma. Oftentimes this is due to the fact that a spicule of bone, or a scar attached to the brain, resulting from the first injury, causes further damage when the brain is shaken or displaced as a result of more moderate head trauma later. Serial e.e.g.'s (electroencephalograms, or brain wave tracings, made at intervals after the injury) may provide some circumstantial evidence as to the possibility of post-traumatic epilepsy. A competent post-mortem examination may enable the pathologist to infer the approximate age of the clot in a case of chronic subdural hematoma thereby helping to determine whether or not it

was causally related to some known traumatic episode occurring weeks or months previously.

It should be stressed that brain injury is by no means synonymous with residual disability. Furthermore, a patient's initial condition may be no true index of the final effects of a head injury. Such patients often sustain multiple injuries. They may be in a temporary state of "surgical shock" or have a temporary loss of bladder function not due to any permanent injury of the nervous system. It is misleading to overemphasize the immediate post-traumatic symptoms. The question is, what does the clinical course show and what are the residual effects following appropriate treatment and convalescence? We have previously emphasized the importance of determining what part of the disability, if any, is referable to organic injury and what part to psychological reactions. The attorney should question medical attendants or examiners in an effort to determine the origin of each complaint or symptom, and should attempt to bring out the evidence available for proving or disproving that the symptoms were caused or aggravated by the trauma sought to be incriminated.

He should focus attention on individual links as well as on composite patterns, mobilizing every manner of evidence tending to prove or disprove causal connections. He should prepare a medical trial brief based on recent treatises or writings of recognized medical authorities setting forth the limits of what is possible and the criteria of proof necessary to establish probable causal connection between the type of traumatic stimulus applied to claimant and the disability imputed to it.

The attorney should consider carefully how each verified effect of the trauma has, in the past, and probably will in the future, affect the daily life, the normal functioning and personality expression, the sense of well-being, the creature comforts, the aesthetic enjoyment and expression, and the earning power of that individual, bearing in mind the type of occupation for which he has been trained.

Careful thought should be given to measures which might alleviate the disability such as possible drugs for controlling convulsive seizures or decreasing the frequency or intensity of the attacks, and possible neurosurgery, in occasional cases, to relieve seizures by reducing the torsion exerted on the brain by scar tissue.

The defense lawyer should thoroughly consider all possible rehabilitation techniques to diminish or abolish disability and personality handicaps, particularly in respect to claimant's ability to work and earn a livelihood.

While organic injury of the brain may be documented by positive neurological findings, a particular exception exists in certain cases involving injury to the frontal lobes (so-called "silent areas") of the

brain. More attention should be paid to the occasional cerebral deficit, or so-called *frontal lobe syndrome,* in which the neurological examination may be negative and yet close study reveals that orderliness of intellectual activity in the affected individual is truly impaired, the lack of inhibitions alter the personality, and that fine points of judgment and of creative ability are lost. The problem is complicated by the fact that all of these findings can be relatively duplicated by the symptoms seen in simple neurosis.

Often the medical record of an injury contributes very materially to the assessment of permanent brain damage and prognosis. In other instances it can be a matter of simply emphasizing gory details, valueless from the medical standpoint, to influence the jury.

One should utilize all possible means of study in probing the pretraumatic personality structure of the individual. Not only do various medical experts have a role to play but information may be gained from friends and associates of the victim. One can assemble the past school records, the results of previous psychometric tests, and opinions of persons with whom the individual works. From this assembled evidence, one can hope to reach a sounder conclusion.

We have alluded to the difficulties of diagnosis. It is fair to say that prognosis, or prediction of future course, may be equally difficult or even more conjectural. It is not desirable to attempt compromise settlements of head injury cases until a competent specialist feels that risks of major complications have materialized, been eliminated by passage of time, or rendered calculable. When the point is reached that the head injury case can be scientifically evaluated, it seems that compromise settlements would go far toward preventing or relieving psychological sequelae and, in other ways, would help both plaintiff and defendant.

SPINAL CORD INJURY

The spinal cord is so important a structure that one regrets that it is ever injured. During World War II we saw many fine, robust lads who could move only their upper extremities (thoracic cord injury) or who could make only a few movements of their shoulders (cervical cord injury).

The favorable cases of spinal cord injury are few, and even transient complete motor and sensory paralysis is rare in this group. Occasionally, complete paralysis of a few hours' or days' duration will permit recovery, but this is not to be expected. The favorable cases comprise a group which can usually be differentiated from the start because of the obviously incomplete nature of the spinal cord lesion. Hysterical paralysis, erroneously diagnosed as a spinal cord lesion, accounts for most of the miraculous recoveries, whether with or without the (often doubtful) benefit of surgery.

Probably, most complete spinal cord lesions should be explored surgically, but the explored group will not likely recover function as a result of "decompression of the injured cord." The bullet and the depressed fragments of bone have *usually* already irreparably damaged the spinal cord. Exploration of less severe spinal cord injuries is always indicated if the operation minimizes the possibility of infection (compound wound). If a patient with *incomplete* paralysis becomes more severely paralyzed, it is considered an indication for surgery. Certainly, surgery is of definite benefit in some instances of spinal cord injury, but the outcome is generally determined by the extent of the original injury. The single definite exception might be in those instances of penetrating injury when infection of a partially injured cord is prevented by proper surgical methods. It is interesting that the degree of fracture or dislocation is a rather unreliable index to the extent of spinal cord injury. At the moment of impact vertebral displacement may sever the spinal cord and yet the vertebrae may return to normal alignment with little evidence of bone damage. On the other hand, we occasionally see marked fractures and dislocations with little evidence of spinal cord or even of nerve root damage.

The syndrome of complete thoracic cord severance consists initially of (1) inability to move the lower extremities; (2) a sensory level below which there is no feeling; (3) loss of the plantar, abdominal and tendon reflexes; (4) loss of control and sensation relative to both bladder and rectal functions.

The life of the paraplegic (both lower extremities paralyzed) patient is threatened only by complications. Bed sores, bladder infection or urinary calculi (stones), and pneumonia are the prominent dangers. A paralyzed patient may live indefinitely. If the patient survives a transverse injury of the spinal cord, the paralyzed extremities will change from a state of flaccidity to a state of spasticity. The Babinski sign and defense reflexes first appear and are followed by return and exaggeration of the tendon reflexes. It is often difficult to explain to family and to patient that the reflex activity does *not* indicate a return of voluntary spinal cord function.[84]

Some Medico-Legal Aspects of Spinal Cord Injuries

It has been remarked that true organic lesions of the spinal cord manifest themselves almost immediately. An appreciable time interval between injury and appearance of disability would be exceptional un-

84. *Spinal cord injuries*: For collections of cases dealing with injuries of spine and spinal cord see Notes, 16 A.L.R.2d 3, 366 *et. seq.* (1951); 102 A.L.R. 1125, 1542, *et seq.* (1936); 46 A.L.R. 1230, 1408, *et seq.* (1927). For an excellent brief study from the medical side, see Kennedy and Denker, *Medico-Legal Aspects of Spinal Cord Injuries,* 11 Mo. L. Rev. 111 (1946), 103 J. of Nerv. and Ment. Dis. 667 (1946).

less one could hypothesize further injury, as for instance, in jackknifing the victim of an automobile accident while lifting him from the ground. Rarely, cases are seen in which a person sustained a fracture of a vertebra in an automobile accident and subsequently had his spinal cord severely injured by injudicious lifting so that he became permanently paralyzed. As the good Samaritan's attempt to give aid is considered to be a consequence of the defendant's culpable behavior in causing the accident, courts hold that the injured person may recover full damages against the original wrongdoer for worsening of his condition by ill-advised first-aid or rescue efforts or even by medical malpractice. The act of the good Samaritan does not break the chain of proximate causation.

The degenerative diseases of the spinal cord cannot be attributed to trauma, and there is considerable controversy as to which, if any, can be aggravated by adequate injury.[85] Plaintiffs suffering from paralysis caused by trauma have been obtaining substantial awards in recent years. Many factors contribute to this result: the psychic effect of the paralytic upon the jury; the fact that the victim's life span may be indefinite; the usual presence of some degree of permanent disability; the risks of various complications which may justify reasonable mental anguish and fears; and expenditures of substantial sums of money for medical and nursing care. Various modalities of personality expression will be affected and a careful comparative inventory should be made of the pursuits of a twenty-four hour day before and after the injury to project the situation accurately. In spite of the dire consequences of spinal cord lesions, a great deal now can be done by way of rehabilitating such patients, and this aspect should be fully explored by defense counsel. Most of the rehabilitation procedures involve retraining rather than surgery, and the claimant would therefore seem to have a duty to accept the benefits of a plausible rehabilitation program tendered to him.

SUMMARY

In neurological or other medical diagnosis it is possible to be right through ignorance as well as through knowledge. If a certain diagnosis is likely in 80 per cent of patients showing particular signs, the inexperienced intern may hit upon the 20 per cent exception when the experienced clinician has indicated the wrong (but 80 per cent likely) diagnosis. Doctors vary in their willingness to be pinned down to a definite diagnosis. Some experienced and well trained surgeons are much more prone to "gamble on a long-shot" than are others. Diagnostic signs differ in their value so greatly that the presence of a

85. Kennedy and Denker, *Medico-Legal Aspects of Spinal Cord Injuries*, 11 MO. L. REV. 111 (1946), 103 J. NERV. AND MENT. DIS. 667 (1946).

single almost pathognomonic (completely diagnostic) sign will outweigh many signs of lesser significance. Too frequently, lay people try to grasp complicated medical facts sufficiently to make an independent decision. At times physicians must have patients or their families make definite decisions in regard to undergoing further medical or surgical procedures. When a clear advantage to the patient is probable as a result of an operative procedure, physicians must not throw the decision back upon the family. Nevertheless, the risks and possible complications must be stated honestly.

In the field of neurological surgery many of the life-saving operations are relatively simple technical procedures, performed at the right time and in the right area of the cranium. A hematoma (blood clot) may be evacuated or an abscess drained. Without this surgical intervention death might have resulted inevitably in hours or days. Death must not be too imminent if an operation is to be successful, even though local anesthesia is used. Surgically speaking, it is often right to explore a patient for a condition which may not be found, but which, if present, can be cured. This wisdom of exploration in certain instances is justified by the small risk of the operative procedure *per se*.

Other more elaborate neurosurgical procedures, very extensive and accurate technically, may fail miserably as far as restoring the patient to a normal state. They can succeed. Operations which carry a high mortality rate must not be undertaken unless the condition requiring operation is a critical one. On the other hand, the very fact that the cards are stacked against the surgeon must not dissuade him from making the effort to save a life which, without his effort, would inevitably be lost. Judgment, as beauty, is a quality which may dare analysis. Integrity, judgment, and the critical virtues which culminate in them are as important to the practice of medicine and surgery as to the practice of law.