FRACTURE OF THE SKULL

IMPORTANCE OF THE EARLY DIAGNOSIS AND OPERATIVE TREATMENT OF FRACTURE OF THE SKULL, WITH CHART OF CLINICAL CLASSIFICA- TION AND TREATMENT, AND GUIDE FOR DETAILED NEUROLOGIC EXAMINATION

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SYNOPSIS

This paper is an effort (*a*) to establish a routine examination for all head injuries possibly associated with fractures, and (*b*) so to classify fractures that a more or less definite policy of treatment may be followed.

The recommendation is made that the house surgeons of all hospitals be instructed that, on admission, these measures should be carried out:

1. All wounds of the scalp which may possibly be associated with a fracture of the skull must be routinely excised and the adjacent bone examined for fracture, which, if found, can by the excision of the infected area be converted from a compound into a simple fracture.

2. All possible fractures of the skull must be subjected to a routine method of examination, every case being (*a*) routinely and systematically examined neurologically; (*b*) the blood pressure routinely taken, at least every hour, for several hours after the injury; (*c*) a lumbar puncture routinely performed; (*d*) repeated ophthalmoscopic examinations routinely made, and (*e*) roentgenograms routinely taken, with, if necessary, exposures in different positions.

With the data obtained by this routine examination, a rather definite policy of treatment may be pursued, such data largely deciding which cases require, and which do not require, an intradural operation.

NECESSITY FOR SPECIAL TECHNIC IN TRAUMATIC INTRACRANIAL SURGERY

Until recently, traumatic intracranial surgery was in the hands of the general surgeon, who usually had no special training for its performance and brought to it habits of technic which not only were totally inadequate to meet the problems presented, but frequently occasioned additional damage to the delicate cerebral tissue, with resulting permanent disability to the patient.

In the early days of the war, it was stated that "it would have been better if the cranial injuries had not been treated surgically, the operative manipulation of the general surgeons having done more harm than good."

The war evolved a thoroughly new understanding of fractures of the skull, and definite features in its treatment are now recognized as essential.

The routine treatment of cases of fracture of the skull, as carried out in the civil hospitals today, is largely of the prewar type. The policy generally followed is this: If the fracture is accompanied by slight symptoms, no operation is performed; no operative differentiation being made between simple and compound fractures. If the immediate cerebral symptoms are severe, an expectant treatment is pursued, unless the patient is in such a grave condition that life is despaired of or localizing symptoms are present. The latter symptoms of terminal compression and the secondary symptoms of meningeal infection, both of which are frequently avoidable by early surgical interference, are regarded as indications for operation, with necessarily a very high mortality.

Remote Effects.—Fracture of the skull results not only in immediate danger to life, but in remote and serious consequences, the patients later developing such severe and lasting symptoms that life becomes more or less unendurable.

Fracture of the skull accompanied by injury to the cerebral tissue or infiltration of blood into the brain substance, causing prolonged increase of the intracranial pressure, is frequently followed by a gliosis. Gliosis, the production of a new connective tissue within the brain, the result of an irritant, is not relievable by any known operative procedure. Chief among the symptoms of a secondary gliosis is persistent headache, for the relief of which a large number of useless operations are performed annually. Another is the development of traumatic epilepsy. Traumatic epilepsy is generally preventable by early operation; but epilepsy, the result of secondary gliosis, is not amenable to operative treatment.

Classification.—Fracture of the skull should primarily be divided into (a) simple and (b) compound fractures.

Simple and compound fractures of the skull present two fundamentally different surgical problems and require different lines of treatment.

Surgical Principles of Treatment.—In simple fractures, the surgical manipulations are limited to (a) the relief of increased intracranial pressure, and (b) the prevention of gliosis; while the surgical problems of compound fracture are primarily: (a) the prevention of intradural

sepsis, in addition to (b) the relief of intracranial pressure and (c) the prevention of gliosis.

The possibility of the associated cerebral trauma being irreparable, a frequent condition, has too often prevented an operation for the relief of cerebral compression.

The surgeon can do nothing to repair lacerated or damaged brain tissue; but if the cerebral compression is removed, Nature will frequently bring about a recovery from a cerebral injury which otherwise would end fatally. Consequently, as it is impossible to estimate correctly the extent of the brain laceration and as the relief of cerebral compression is the only surgical end attainable, the possibility of associated injury to the cerebral tissue should largely be disregarded.

Similarly, the dividing of fracture of the skull into bursting, bending, linear, or comminuted has largely confused the real surgical consideration, namely, whether the fracture is or is not depressed.

Linear fractures, simple or compound, cause no immediate symptoms unless associated with intracranial hemorrhage or injury to a nerve as it leaves the skull.

I have been impressed by the frequency with which linear fractures of the skull are overlooked, some being followed by distressing symptoms, avoidable by early recognition and operation.

A linear fracture of the base passing through the petrous portion of the temporal bone causes permanent deafness associated with distressing tinnitus or vertigo. It is because of the persistence of the vertigo following unrecognized fracture through the base that many of the patients first consult me.

Neurologic Examination.—Every case of cranial trauma, even though the acute symptoms rapidly disappear, should be subjected to a routine neurologic examination, which will frequently reveal positive evidence of fracture otherwise overlooked. (See Guide for Detailed Neurologic Examination for hospital interns, page 147).

DIAGNOSIS OF INCREASED INTRACRANIAL PRESSURE

Importance of Systematic Blood Pressure Examination.—The blood pressure of every patient with a possible fracture should be repeatedly taken, at least every hour for the first few hours, until a persistently rising blood pressure or pulse pressure is definitely excluded. An increasing intracranial pressure, sufficient to cause a persistently rising blood pressure, if not early recognized and relieved by operation, uniformly results in sudden death from respiratory paralysis.

CASE 1.—A man fell and struck his head while intoxicated. On admission he was in deep coma, which was thought to be largely the effects of alcohol. There were no external signs of fracture. Blood pressure was 160. A few

hours later Cheyne-Stokes' respiration developed; the pulse became strong and regular, and the blood pressure rose to 210.

Necropsy.—A fracture through the base with intradural hemorrhage was revealed. Immediate decompression might have saved him.

Of equal importance is an increasing disproportion between the systolic and diastolic blood pressure; namely, a disproportionally rising pulse pressure, usually associated with a falling pulse. A rising systolic blood pressure is seldom present unless the medulla itself is involved, but a rising pulse pressure is common in acute compression.

LOW DIASTOLIC PRESSURE A CONTRAINDICATION TO OPERATION

If on admission the diastolic pressure is below 55, the patient is in profound shock. The slightest manipulation will then send the diastolic pressure a little lower, whence it will not rise. Before the restoration of the diastolic pressure to a higher level, no surgical procedure should be instituted. The patient should not be moved, disrobed, nor should his wound be dressed beyond what is absolutely necessary to control bleeding. He should be kept warm.

CASE 2.—This patient suffered a compound fracture of the temporal region. He was in excellent mental condition, conversing freely about the accident. The pulse was poor, as a result of his having lost considerable blood, which, however, had stopped at the time of examination.¹

Operation.—Elevation of the depressed fracture was performed, uncovering a tear in the lateral sinus, which again bled freely. Hemorrhage was controlled by transplantation of a piece of fascia lata. The dura was not injured. During operation the anesthetist reported the patient was in a serious condition. Death occurred from shock, without the patient's regaining consciousness.

Value of Ophthalmoscopic Examination.—The fundus in every case of suspected fracture of the skull should be examined within the first few hours. This should be repeated daily as long as the diagnosis is in doubt. Systematic ophthalmoscopic examination may show moderate increase in the intracranial pressure when absolutely no other symptoms are present.

In my experience a typical "choked disk" is never seen in fractures of the skull. However, fulness of the vessels and a slight degree of blurring at the margin of the disk is always present with increased intracranial pressure. I have observed a primary blanching of the whole retina, probably from the ischemia of the vessels from shock, give place to a mild papillo-edema as the intracranial pressure rose from cerebral edema.

1. This man's blood pressure was not taken. It is because of this case that I have since always insisted on a routine examination of the blood pressure, for I have no doubt that at the time of the operation the diastolic pressure was very low. Had this been shown we would not have operated.

Lumber Puncture As a Diagnostic Measure.—In all suspected fractures of the skull there should be performed a routine lumber puncture, blood in the fluid being presumptive evidence of intradural hemorrhage.

A type of intracerebral hemorrhage, not associated with bloody cerebrospinal fluid, is injury to the middle meningeal artery, the resulting hemorrhage being between the bone and the dura. Following an injury in which there is perhaps a moment or two of unconsciousness, later consciousness is entirely regained, "the free interval," followed by cerebral symptoms. These cases result most satisfactorily, providing operation is not deferred until a vascular breakdown is threatened.

CASE 3.—A boy fell from a window, was dazed but never unconscious, and then appeared perfectly normal. He walked into the hospital apparently not injured except for a bruise on the side of his head. There was no external wound. The following day, weakness of the arm developed; later, convulsion, followed by unconsciousness, with paralysis of one arm and leg. The roentgen ray revealed a linear fracture.

Operation.—This exposed the fracture involving the anterior branch of the middle meningeal artery. A thick, extradural clot was revealed, on evacuation of which, recurrence of bleeding from the tear in the middle meningeal artery occurred. This was ligated. The patient made an uneventful recovery.

Lumbar Puncture as a Therapeutic Measure.—In many cases of cerebral trauma the irritation from hemorrhage and cerebral disorganization occasions an increase in the cerebrospinal fluid, which adds to the already increased intracranial pressure. This "vicious circle" may be broken by a lumbar puncture.

CASE 4.—A man suffered a fracture of the skull. He was in deep coma; there was intense papillo-edema, and bloody cerebrospinal fluid under pressure; a depressed fracture over the temporal region with a tear in the lateral sinus.

Operation and Result.—A large extradural clot was evacuated. Hemorrhage was controlled by ligation of the sinus. Three weeks later the patient was semicomatose, delirious, restless and controlled only by restraint. There was marked papillo-edema. Lumbar puncture liberated a large quantity of cerebrospinal fluid under pressure. There was immediate improvement. The second puncture was followed by permanent relief.

Roentgen-Ray Examination.—A routine roentgen-ray examination of all head injuries frequently discloses very extensive fractures, even going beyond the median line, unassociated with any symptoms. It is necessary, however, that a negative roentgen-ray finding should not be taken as positive evidence of the absence of fracture. Several exposures in different positions may be necessary to demonstrate the presence of a fracture even when it is depressed.

CASE 5.—A woman was struck on the top of the head and over the left eye. When she was admitted to the hospital, there was a wound in both regions. The upper one was excised, the lower one sutured without excision. The first roentgen-ray diagnosis was: "Possible fracture of the skull." It was not until the third roentgenogram that a diagnosis of depressed frontal fracture was made.

CASE 6.—A man was struck on the head, probably by a sandbag, while semi-intoxicated. On admission, he was in semicoma, thought to be largely alcoholic in origin. There was slight hemorrhage from the ear; the blood pressure was 140. Lumbar puncture revealed slightly bloody cerebrospinal fluid under pressure. The following morning he was conscious and rational. The blood pressure was 160. Four hours later the blood pressure was 170. There were no cerebral symptoms except that the man talked rather too freely, appeared nervous and wanted to leave bed. The hemorrhage from the ear was thought to be from the external canal as he heard well. There was mild papillo-edema, accounted for by cardiovascular disease, which was otherwise manifest. The roentgenogram was negative. Clinical diagnosis was delirium tremens. Twenty hours after admission, the blood pressure was 200. He was taken to the operating room, thought to be suffering from alcoholism. In view of the rising blood pressure it was decided that if the cerebrospinal fluid was found to contain blood a decompression operation would be performed. He was given ether because he could not be restrained. On removing some cerebrospinal fluid, the heart suddenly stopped.

Necropsy.—There was separation of the lambdoid suture and a linear fracture of the left petrous bone, rupture of the tympanum, subdural hemorrhage at the tips of both frontal lobes, with laceration of brain at the frontal tips. General cardiovascular disease was present. The patient should have been decompressed when the blood pressure rose to 170, in the presence of mild papillo-edema, rising blood pressure and bloody cerebrospinal fluid. The relief of the increased intracranial pressure according to the necropsy findings offered a fair prospect of recovery.

Compound Fractures.—I have been impressed with the large number of apparently slight compound fractures which terminate fatally, death resulting from a subsequent infection of the meninges long after the first slight symptoms of cerebral trauma have passed, the sepsis entering by way of a linear fracture communicating with a septic skin wound. In many cases, the fracture is overlooked from failure of routine excision and examination of all scalp wounds, which possibly may be associated with fracture.

CASE 7.—A woman suffered a lacerated wound of the parietal region and a slight wound over the eye. The upper wound was explored and no injury to the bone was found. Both wounds were sutured. Eleven days later, the patient became irrational. Exophthalmus developed from pus behind the eyeball. The third roentgenogram revealed extensive linear fracture of the frontal bone, reaching the roof of the orbit. The whole area was bathed in pus. Death occurred seven days later.

Necropsy.—Meningitis was found around the site of the fracture.

CASE 8.—A child fell from a window sustaining a slight wound above the eye. There were no cerebral symptoms. The fourth day after admission, the temperature was high. The roentgen ray revealed a linear fracture of the vault. At operation an enormous quantity of pus was evacuated from under the temporal muscle. A long linear fracture was discovered through which at one place the dura protruded. On removal of bone, herniation of the cerebral tissue through the tear in the dura occurred. The abscess of the brain was evacuated. The patient made an uneventful recovery.

Primary Excision.—In every case of possible fracture of the skull, all wounds around the scalp should be routinely excised, and the incision extended in whatever direction necessary so that the skin flaps may be pulled apart and the bone exposed. This should be the routine in every hospital service.

If a fracture is not found, the wound, which primarily was infected, having been excised, can be treated as a primary aseptic wound and closed. To allow of complete closure, however, the excision must be complete and performed within six hours of the time of its infliction, as bacteria do not multiply within the tissue for at least six hours. If, during excision, a fracture is seen, it can then be decided what type of operation is necessary.

CASE 9.—A man was struck on the head by a heavy hammer falling from a height, causing a compound depressed fracture in the frontal region. On admission, within an hour after the accident, the patient was in good condition and mentally clear.

Operation.—Extensive incision of the skin and depressed area of bone was made. A large tear was found in dura, also a slight subdural hemorrhage. Lumbar puncture allowed of tight closure of the dura without herniation, secondary edema not having developed. There was tight closure of the skin wound; a stab wound was made away from the defect to allow for drainage. The following day the patient declared he was well and requested to be transferred to his home.

CONCLUSIONS .

The principles underlying treatment of fractures of the skull should be: repeated routine recording of the blood pressure, a rising blood pressure or a disproportionately increasing pulse pressure calling for immediate operation; routine examination of the eyes, the development of papillo-edema not accounted for by a vascular lesion calling for operation; immediate lumbar puncture to decide whether there is a hemorrhage within the dura or not, presence of blood in the cerebrospinal fluid making fracture probable but not calling for operation; routine neurologic examination in all cases of suspected fracture.

All wounds of the scalp should be excised, the area of excision being extended to allow of investigation of the bone directly under and in the immediate vicinity of the wound. In the presence of a linear fracture the area should be excised and it should be converted into a simple fracture with primary closure.

CHART OF CLINICAL CLASSIFICATION AND TREATMENT OF FRACTURES OF THE SKULL

A. Simple fracture of the skull may be divided into:

(1) Simple linear	(a) without symptoms. Treatment: prolonged rest.

- (b) with symptoms of compressions. Treatment: operation for relief of compression by (1) removal of extradural or intradural clot with control of hemorrhage by ligation or obliteration; (2) decompression, and (3) lumbar or ventricular puncture.
- (2) Simple depressed (c) with or without cerebral symptoms. Treatment: operation for elevation or removal of depression with or without repair of dura; relief of compression.
- B. Compound fractures may be divided into
 - (3) Compound linear (d) without cerebral symptoms. Treatment: operation for immediate conversion of compound into simple by excision.
 - (e) with symptoms of compression. Treatment: operation for immediate conversion of compound into simple by excision of skin and bone; relief of compression.
 - (4) Compound depressed (f) with or without cerebral symptoms. Treatment: operation for conversion of compound into simple fracture by excision, elevation or removal of depression, relief of compression, control of hemorrhage, repair of dura, closure of defect, drainage when necessary by stab wound away from defect.

GUIDE FOR DETAILED NEUROLOGIC EXAMINATION

The guide is designed to enable hospital interns or trained attendants, without special training in neurology, to conduct a detailed examination by eliciting and recording the details of all objective and subjective symptoms.

The examination is divided into: I. General Neurologic symptoms. II. General Neurologic Examination. III. Cerebral Localization. IV. Examination of Cranial Nerves.

Suggested terms, with possible interpretations, and methods of testing, as well as the normal reactions, are placed in brackets. An asterisk (*) in the margin indicates examination for unconscious patients. The general sections are indexed by roman numerals, the chief symptoms or manifestations by capital letters, and the individual details by alternate letters and numbers.

DIRECTION FOR USING GUIDE

The examination begins under the heading General Symptoms.

At the completion of the examination all outstanding symptoms and abnormal findings are recorded on the record sheet, followed by the index numbers and letters according to the guide, enabling a ready reference to the exact location of each detail. Example: "Papillo-edema, IV, B—1." When a general symptom has a direct bearing on the localization it should be cross-indexed. Example: "Dizziness, I. D. and IV, F—2d."

GUIDE FOR NEUROLOGIC EXAMINATION

(Record Sheet to Be Followed by House Surgeon)

Full Name.....

Address

Hospital No.....

*Résumé of History**Résumé of Outstanding Symptoms**Résumé of Abnormal Neurologic Findings*.....
Signature of House Surgeon

Date

I. GENERAL SYMPTOMS

- (A) Headache? severity ("mild," "intense," "bursting," "throbbing," "lacerating");
location (frontal, temporal, "behind the eyes," pituitary, occipital, vertex);
in attacks or constant;
initial appearance (date).
- (B) Pain? situation (nose, eyes, ears, arms, legs, etc.);
duration;
initial appearance;
in attacks or constant.
- * (C) Vomiting? frequency;
type (projectile or regurgitant);
initial appearance.
- (D) Dizziness? in attacks or constant;
degree (transient giddiness, swaying, falling);
duration;
initial appearance;
description of (if objects appear to patient to move);
duration (momentary or continued).
- * (E) Convulsions? general or localized;
part involved.
associated with unconsciousness?
preceded by aura? (description of aura: visual, flashes of light, objects seen; auditory, tones or music heard).
during attack: head to right, to left;
eyes to right, to left;
arms to right, to left;
legs to right, to left.

- * (F) Stupor? initial appearance;
 in attacks?
- (G) Numbness? situation;
 in attacks;
 initial appearance.
- (H) Tingling? situation;
 in attacks;
 initial appearance.

II. GENERAL EXAMINATION

- * (A) Head:
 1. Wounds, description of.
 2. Bleeding from ear: right, left.
 3. Bleeding from nose: right, left.
 4. Scars: description of.
- * (B) Extremities:
 1. Paralysis of arm? right, left.
 2. Paralysis of leg? right, left.
 3. Anesthesia of arm? right, left.
 4. Anesthesia of leg? right, left.
- * (C) Reflexes:
 1. Superficial:
 - (a) epigastric;
 - (b) abdominal;
 - (c) cremasteric.
 2. Deep:
 - (a) knee;
 - (b) ankle;
 - (c) Babinsky;
 - (d) Kernig.
 3. Sphincters:
 - (a) loss of bladder control?
 - (b) loss of bowel control?
 4. Vasomotor:
 - (a) abnormal flushing?
 - (b) abnormal sweating?

III. CEREBRAL LOCALIZATION

- (A) Frontal Lobe:
 1. Memory for:
 - (a) names (father's name; street where lives);
 - (b) events.
 2. Orientation.
 3. Affections.
 4. Aphasia:
 - (a) for names or other parts of speech;
 - (b) ability to repeat sentence after examiner.
- (B) Temporal Lobe:
 1. Aphasia:
 - (a) ability to recognize objects and state use, but inability to name ("knife," "key");
 - (b) ability to recognize proper name and ability to repeat name.

2. Uncinate gyrus symptoms:
 - (a) hallucinations of smell;
 - (b) hallucinations of hearing
3. Hemianopsia:
 - (a) right-sided? left-sided?
 - (b) for form;
 - (c) for colors.
4. Dreamy state?

(C) Parietal Lobe:

1. Sensory symptoms:
 - (a) paresthesia (touch, pain, temperature);
 - (b) anesthesia;
 - (c) astereognosis;
 - (d) muscle sense.
2. Motor symptoms:
 - (a) paralysis: where, duration;
 - (b) paresis: where, duration;
 - (c) convulsive seizures (Sec. I-E), part involved, consciousness lost?

(D) Occipital Lobe:

1. Hemianopsia: right-sided? left-sided?
2. Visual hallucination: right-sided? left-sided?

(E) Cerebellum:

1. Dizziness;
2. Nystagmus;
3. Romberg;
4. Disturbances of gait;
5. Ataxia;
6. Adiadokokinesis.

IV. CRANIAL NERVES

(A) First ("olfactory"; special sense):

1. Smell (perfumery): right nostril? left nostril?

(B) Second ("ophthalmic," special sense):

1. Fundus examination;
2. Vision: right eye? left eye?

* (C) Third, Fourth and Sixth (ocular movements):

1. Pupils:
 - (a) equal;
 - (b) contracted;
 - (c) dilated;
 - (d) react to light;
 - (e) react to accommodation.
2. External ocular movements:
 - (a) diplopia: convergent? right, left; divergent? right left?
 - (b) spontaneous nystagmus to right? to left?
 - (c) conjugate deviation to right? to left?

(D) Fifth ("Trifacial," Sensory and Motor):

1. Sensory portion:

- (a) anesthesia of { supra-orbital* (cornea)
- (b) neuralgia of { infra-orbital
- (c) taste in anterior two thirds of tongue: (sugar, salt).

2. Motor portion:

- (a) buccinator;
- (b) masseter.

3. Vasomotor portion (herpes of brow; of lip).

* (E) Seventh (Facial, Motor, Sensory):

*

1. Motor Portion:

- (a) Paralysis or paresis: right? left?

Part involved:

- Brow?
- Lower eyelid?
- Mouth?
- Cheek?
- Palate?

2. Sensory portion (taste in anterior two thirds of tongue):

3. Vasomotor:

Herpes of ear?

(F) Eighth ("Auditory" and "Vestibular"; Special Senses):

1. Auditory portion:

- (a) Deafness: right ear? left ear?

Hearing { watch
 { whisper right ear? left ear?
 { voice

(normal or otherwise)

- (b) Tinnitus? (special auditory tests to be conducted by specialist)

(a) Tuning fork;

(b) Weber referred to: right, left;

(c) Bone conduction:

Duration of? (seconds) right, left.

*

2. Vestibular portion:

*

- (a) Spontaneous nystagmus;
- (b) Spontaneous vertigo;
- (c) Spontaneous pointing deviation (downward from shoulder),
right arm, left arm.

(d) RÉSUMÉ OF INDUCED VESTIBULAR REACTIONS

(To be filled in by expert after special vestibular tests have been conducted)

1. From turning to right:

Nystagmus;

Past pointing: right arm, left arm;

Falling.

2. From turning to left:

Nystagmus;

Vertigo;

Past pointing: right arm, left arm;

Falling.

3. From douching right ear:
 - Nystagmus;
 - Vertigo;
 - Past pointing: right arm, left arm;
4. From douching left ear:
 - Nystagmus;
 - Vertigo;
 - Past pointing: right arm, left arm;

SPECIAL VESTIBULAR TESTS (To be conducted by expert)

1. Turning to right (reactions induced by turning to right, head forward 30 degrees):
 - (a) Induced nystagmus (normal, horizontal to left)
 1. amplitude
 2. duration (normal, 26 sec.)
 3. direction (normal, horizontal to left);
 - (b) Induced vertigo (normal, to left);
 - (c) Induced past pointing
 - (shoulder from above, normal, to right);
 - Right arm to—
 - Left arm to—
 - (d) Supplementary:
 - Head forward: falling (normal, to right)
2. Turning to left (turning to left, head 30 degrees forward):
 - (a) Induced nystagmus:
 1. amplitude;
 2. duration (normal; 26 sec.);
 3. direction (normal; horizontal to right).
 - (b) Induced vertigo (normal; to right);
 - (c) Induced past pointing
 - (shoulder from above, normal, to left);
 - Right arm to—
 - Left arm to—
 - (d) Supplementary:
 - Head forward: falling (normal, to left).
3. Caloric right (reactions induced by douching right ear with cold water, head forward 30 degrees):
 - (a) Induced nystagmus (normal; rotary to left).
 1. amplitude;
 2. duration;
 3. direction.
 - (b) Induced vertigo (normal, to left);
 - (c) Past pointing (shoulder from above, normal, to right);
 - Right arm to—
 - Left arm to—
 - (d) Supplementary:
 1. Head back to 60 degrees:
 - (a) nystagmus (normal; horizontal to left);
 - (b) past pointing (normal; to right);
 - Right arm to—
 - Left arm to—

2. Caloric right (reactions induced by douching right ear with cold water, head forward 30 degrees):
 - (a) Induced nystagmus (normal, rotary to left):
 1. amplitude;
 2. duration;
 3. direction.
 - (b) Induced vertigo (normal, to left);
 - (c) Past pointing (shoulder from above, normal, to right);
 - Right arm to—
 - Left arm to—
 - (d) Supplementary:
 1. Head back 60 degrees:
 - (a) nystagmus (normal, horizontal to left);
 - (b) past pointing (normal, to right);
 - Right arm to—
 - Left arm to—
2. Caloric left (reactions induced by douching left ear, head forward 30 degrees):
 - (a) Induced nystagmus (normal, rotary to right):
 1. amplitude;
 2. duration;
 3. direction.
 - (b) Induced vertigo (normal, to right);
 - (c) Past pointing (shoulder from above, normal, to left);
 - Right arm to—
 - Left arm to—
 - (d) Supplementary:
 1. Head back 60 degrees:
 - (a) nystagmus (normal, horizontal, to right);
 - (b) past pointing (normal, to left);
 - Right arm to—
 - Left arm to—
- * (G) Ninth ("glossopharyngeal," special sense, sensory motor);
 - Taste;
 - * Swallowing.
- (H) Tenth ("pneumogastric," motor and sensory);
 - Hoarseness;
 - * Rapidity of heart.
- (I) Eleventh ("spinal accessory," motor);
 - Trapezius muscle;
 - Sternocleidomastoid;
 - Shoulder dropping.
- (J) Twelfth ("hypoglossal," motor);
 - How is tongue protruded?