THE INNER EAR

INCLUDING

OTONEUROLOGY, OTOSURGERY AND PROBLEMS IN MODERN WARFARE

BY

JOSEPH FISCHER MD

AND

LOUIS E. WOLFSON MD

WILLIAM HEINEMANN · MEDICAL BOOKS · LTD

THE INNER EAR

This page intentionally left blank

THE INNER EAR

INCLUDING

OTONEUROLOGY, OTOSURGERY, AND PROBLEMS IN MODERN WARFARE

By

JOSEPH FISCHER, M.D.

Staff Member, Beth Israel Hospital, Boston; formerly Associate of Adam Politzer and Senior Otolaryngologist with Gustav Alexander, Policlinic of Vienna

AND

LOUIS E. WOLFSON, M.D.

Instructor in Ear, Nose, and Throat, Tufts Medical School; Senior Surgeon in Ear, Nose, and Throat, Boston Dispensary

LONDON

WILLIAM HEINEMANN

(MEDICAL BOOKS) LTD.

1943

PRINTED BY
WAVERLY PRESS, INC.
U. S. A.

Contents

Authors' Prefaces

Through twenty years of postgraduate lecturing, I have constantly been asked the same question: "What book would you recommend for studies on the labyrinth and on otoneurologic problems?" I could never answer satisfactorily, because all that is available are either the ordinary textbooks that deal with the subject in a rather brief and elementary way, or the encyclopedias and handbooks of anatomy, physiology, neurology, etc., in which the respective chapters comprise large-scale dissertations delving into trifling details, so that the reader soon finds himself lost in the depths of science. One could also use the most important original articles on the labyrinth by authors of the various countries. However, this requires a certain knowledge of the subject, and would not give a satisfactory survey of the knowledge of the labyrinth.

Repeatedly I was asked by my students to write down my lectures on the labyrinth, which included instruction on anatomy, physiology, clinical practice, and operative technic on cadavers. I am fully aware of the great difference between the cold printed words of a book and the living lecture using anatomic specimens or patients, with demonstration of surgical procedures, and followed by a general discussion. Despite this, I have finally decided to bridge the gap between the usual textbooks and the voluminous encyclopedias and to write a treatise on the subject. Since the diseases of the middle ear are exhaustively discussed in the various textbooks, and since the function of the cochlear apparatus is generally known, the main attention is given in this book to the labyrinth and its central pathways.

Before I began on this difficult task, I scrutinized my registration book, which contains the signatures of all the students who have taken the various courses with me. I found two main groups of students. One group consisted of rather older otolaryngologists with great clinical experience and skill, who could not, however, keep pace with current progress in theory and research. The other group was represented by well educated young physicians with great theoretic knowledge (chiefly interns and residents) but without clinical experience.

This differentiation gave me the basis for the structure of my book. Almost every topic occurs twice—once in the chapters on physiology, where the various theories and hypotheses are discussed and references to the bibliographic material are brought out, and again in the chapter on functional tests, where indications, technic, clinical significance, and evaluation of the various tests are critically described In this manner each reader can find just what he is looking for without having to plow through pages of theory and literature.

In the discussion of the inflammatory diseases of the labyrinth, a new principle of classification is used, as outlined by my former chief Alexander and myself. Particular stress has been placed on the pathologic anatomy of the various forms of labyrinthine disease; each is illustrated by photomicrographs. This emphasis stems from my conviction that correct diagnosis and proper treatment depend on an exact knowledge of the pathologic basis. The indications for surgical intervention, as used in our clinic, and the technics of the various operations have been outlined. In the complex matter of otoneurology, the important role played by the otologist in rendering diagnostic aid to the neurologist is exemplified in the differentiation between peripheral and central lesions.

The illustrations in the chapters on anatomy and physiology are, for didactic reasons, chiefly schematic and diagrammatic, while in the clinical sections photomicrographs are shown. The diagrams were made by Dr. Louis Bergmann, to whom I wish to express my appreciation for his artistic drawings. All macro and microphotographs used in this book are from specimens in my own collection.

JOSEPH FISCHER

As an otologist in active practice for more than twenty years, the various special problems of this field of medicine have been of particular interest to me. Every year or two I have managed to visit several of the special clinics either in this country or abroad. It has been especially interesting and instructive to see the various ways in which our present otologic problems are treated.

In this book, an effort has been made to review the important contributions in otology and also their relation to otoneurology. The subjects of Ménière's disease and otosclerosis are brought thoroughly up to date. In describing the intracranial complications, particular attention is given to the processes in the posterior cranial fossa, with special reference to their connection with the labyrinth. In the section on cerebellar abscess, the diversity of opinion between the otologist and neurosurgeon is critically discussed, and the interrelationship of their domains is shown in the discussion of the various diseases of the nervous system.

I wish to give grateful thanks to my many teachers and friends, many of whom are no longer with us: Neumann, Alexander, and Ruttin of Vienna; Jansen, Bruehl, and Passow of Berlin; Holmgren of Stockholm; Bárány of Upsala; Le Maître of Paris. And I wish to express my appreciation to Lempert in New York and Hughson in Abington, Pennsylvania, for their many kindnesses to me.

LOUIS E. WOLFSON

Boston, February, 1943

I

Clinical Anatomy

By *Joseph Fischer*

1. Nomenclature

The designation "clinical anatomy" is given to these studies to differentiate them from the descriptive treatment of anatomy found in most textbooks. The main attention is given to topographic relationships with respect to surgical procedures and to those anatomic details that have a clinical significance. Since it is often difficult to visualize anatomic relationships, illustrations are used chiefly in a schematic or half-schematic way to simplify matters, while for demonstration of pathology only photomicrographs are used.

The best way to get a proper conception of topographic relationships is to dissect petrous bones in various planes. Those who are interested in this subject are referred to the book about macroscopic and microscopic dissection of the ear by G. Alexander and J. Fischer.

In discussing the anatomy of the inner ear, I follow the nomenclature proposed by my former chief, Alexander. He divides the inner ear into cochlea and labyrinth. The latter consists of the vestibule and the semicircular canals. Hence the term "labyrinth" is applied to the non-cochlear part of the inner ear. The nervus vestibularis is spoken of as nervus labyrinthicus. The same holds true for the ganglion vestibulare, which he calls ganglion labyrinthicum.

2. Topographic Relations within the Petrous Bone

If it were possible to visualize a transparent petrous bone, with the inner-ear spaces filled with stained fluids, three spaces would be outlined: (1) a perilabyrinthine space, between the surface of the petrous bone and the inner ear; (2) a perilymphatic space, between the bony and the membranous inner ear; (3) an endolymphatic space within the membranous inner ear (Fig. 1).

The *perilabyrinthine space* is not very definite and shows great anatomic variation. There may be a whole system of pneumatic cells extending from the mastoid, antrum, epitympanum, or eustachian tube down to the tip of the pyramid, or there may be very few cells or none at all—so that it cannot properly be called a space in the same sense as the perilymphatic and endolymphatic spaces, which are real, definitely outlined spaces filled with fluid. The clinical importance of this region can best be seen in the fact that most of the anatomic studies in the various countries are made not by anatomists but by otologists.

Mouret and Portmann (France) often found on the tip of the pyramid large cells communicating with the perilabyrinthine space. They described two groups of cells in the apex: one, the external inferior group, originating from the eustachian tube; the other, the internal superior group, extending from the labyrinthine cells. A suppuration of the pyramidal tip can therefore come either directly from the eustachian

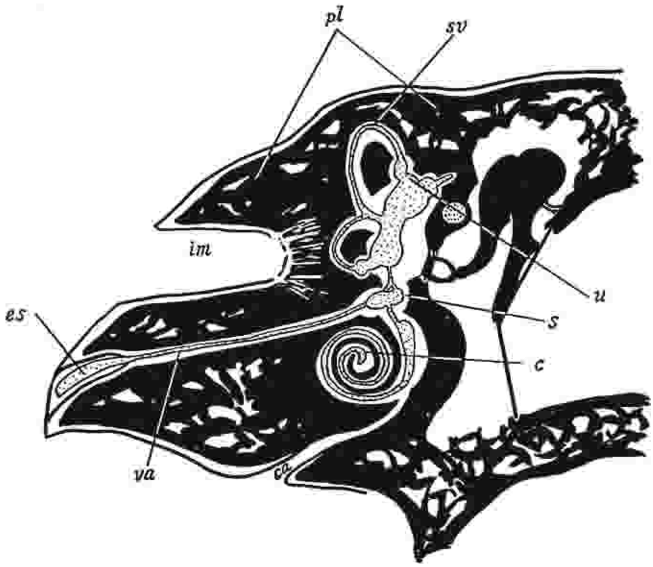

FIG. 1. SCHEMATIC ILLUSTRATION OF INNER EAR

black = endolymphatic space; white = perilymphatic space; *pl* = perilabyrinthine cells; *im* = internal auditory meatus; *es* = endolymphatic sac; *ca* = cochlear aqueduct; *va* = vestibular aqueduct; *s* = saccule; *u* = utricle; *c* = cochlea; *sv* = superior vertical canal.

tube or indirectly (over the perilabyrinthine cells) from the tympano-antral cells. Belinoff and Balan (Bulgaria) examined 40 petrous bones and found three different types of pyramidal structure, namely, the pneumatic, the diploetic, and the mixed type. In 62 per cent of these bones, the structure of the pyramidal tip did not correspond with the structure of the mastoid.

Myerson, Rubin, and Gilbert studied the anatomy of 200 petrous bones and found pneumatization of the apex in 11 per cent, while Hagens observed it in 34 per cent. Frenckner (Sweden) found in more than onefourth of his cases a pneumatized apex. He described the various cell passages, such as the posterosuperior, the inferior, and the tractus subarcuatus. The various cell systems joined and formed a common cell system within the pyramid.

J. R. Lindsay (Chicago) examined 100 petrous bones with the following results: pneumatization in the posterosuperior area (with cells from the epitympanum) in 36 per cent, pneumatization in the posteromedial area (with cells from the mastoid) in 25 per cent, pneumatization in the infralabyrinthine area (with cells from the mastoid to the jugular bulb or round window niche) in 25 per cent, pneumatization in the tip of the pyramid in 21 per cent.

The clinical importance of this region has been stressed by Eagleton, Friesner, Ramadier, Kopetzky, Brunner, etc. (p. 231).

The *perilymphatic space* lies between the bony and the membranous inner ear, and is filled with a fluid called the perilymph. Its communication outside the petrous pyramid is called the aquaeductus cochleae. It has two openings, one within the inner ear—apertura interna—in the scala tympani, or first turn of the cochlea, and the other—apertura externa—outside the pyramid on its inferior surface, as shown in FIGURE 1. There the duct debouches subdurally into the cerebrospinal spaces containing cerebrospinal fluid, and therefore communicates with the brain spaces. This anatomic fact is of great practical importance, since this is a pathway of infection from the inner ear to the cranial fossa in cases of meningitis and brain abscess. Conversely, pathologic conditions such as brain tumor, hydrocephalus, etc., which are accompanied by increased intracranial pressure, may likewise sooner or later produce changes in the inner ear (congestive inner ear or choked labyrinth), as I have shown in microscopic studies.

The *endolymphatic space* lies within the membranous inner ear and contains a fluid called the endolymph. Its communication is called the aquaeductus vestibuli. It has an internal aperture in the vestibule, where the canal begins from the ductus utriculosaccularis, and an external opening, located on the posterior surface of the petrous bone, halfway between the internal auditory meatus and the lateral sinus (FIG. 1). Studies on the anatomy of the endolymphatic duct and sac have been carried out recently by Guild, Anson, Bast, etc.

Bast described a valve that projects into the utricle and guards the utricular opening into the utriculo-endolymphatic duct. He believes that the valve prevents a sudden outflow of endolymph from the utricle. Perlman and Lindsay corroborate the presence of a utriculo-endolymphatic valve in man and in certain animals, which functions in maintaining the content and volume of the utricle and the semicircular canals.

The chemical composition of the peri- and endolymph fluids is the same, but anatomically they are separated, because the endolymphatic system is a closed system blindly intradural.

The dura in this region is very adherent and can easily be torn in the course of a labyrinth operation. It is therefore advisable to sever the

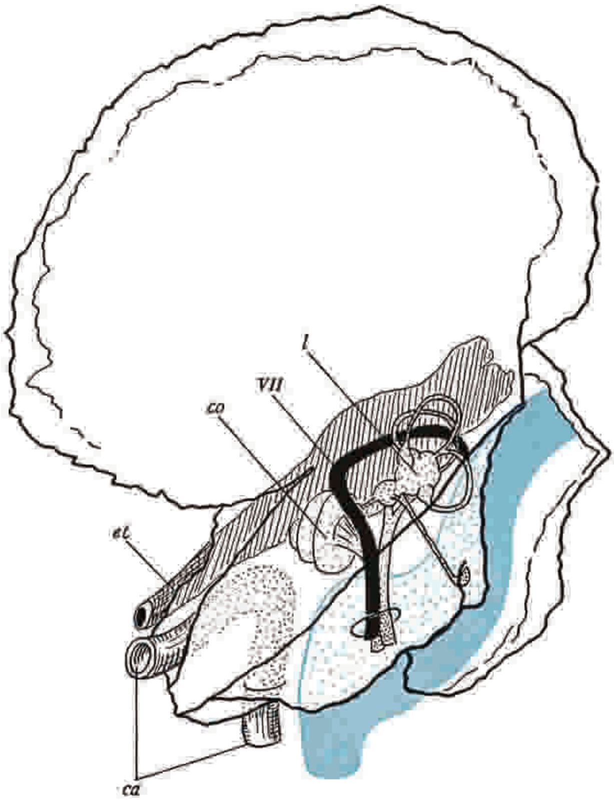

FIG. 2. DIAGRAM SHOWING TOPOGRAPHY OF INNER EAR

blue = sigmoid sinus; *ca* = carotic artery; *et* = eustachian tube; *VII* = facial nerve; *co* = cochlea; *l* = labyrinth.

attachment with a sharp instrument before chiseling on the posterior surface of the pyramid.

FIGURE 2 shows schematically the topographic relations of the various parts within an assumed transparent petrous bone.

3. THE BONY INNER EAR

The bony inner-ear structure consists of three parts, a central, an anterior, and a posterior part; these are, in order, the vestibule, the cochlea, and the semicircular canals.

The *vestibule* is oval-shaped. For purposes of demonstration, we shall assume a cube with six walls. The lateral wall constitutes also the medial wall of the middle ear, as seen in FIGURE 3, which shows the two windows—the fenestra ovalis, closed by the footplate of the stapes, and the fenestra rotunda, closed by the secondary membrane. Between these two windows

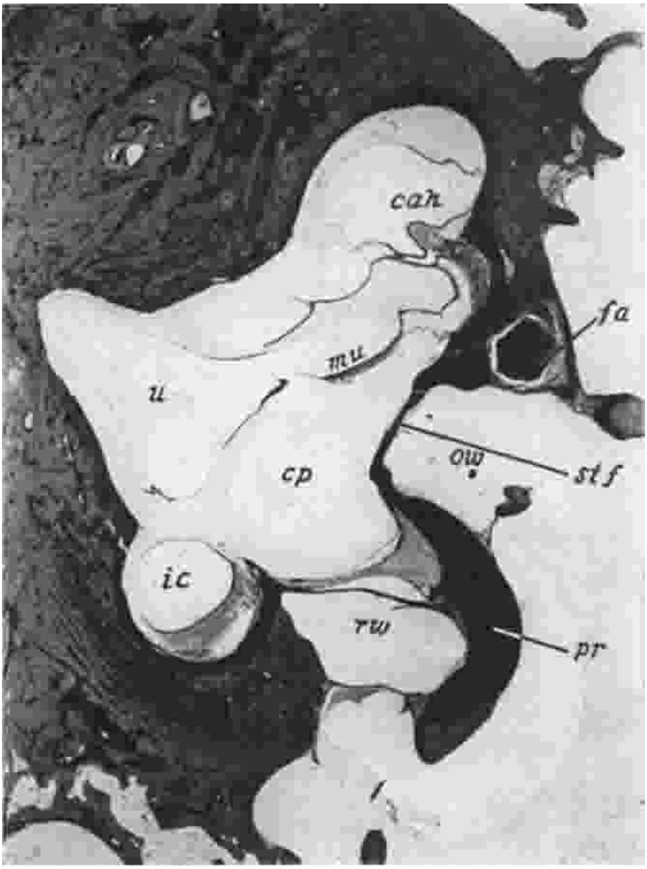

FIG. 3. VERTICAL SECTION THROUGH MIDDLE AND INNER EAR

pr = promontory; *rw* = round window; *ow* = oval window; *st f* = stapes footplate; *fa* = facial nerve; *cah* = crista ampullae horizontalis; *mu* = macula utriculi; *u* = utricle; *cp* = perilymphatic cistern; *ic* = inferior vertical canal.

is the promontory, which corresponds to the first turn of the cochlea. Above the oval window lies the fallopian canal, and above that, almost in the superior wall of the vestibule, the prominence of the horizontal semicircular canal is visible. The medial wall of the vestibule (FIG. 4) shows two depressions in the bone, one lying superoposteriorly, called the recessus ellipticus, and the other in front and below, called the recessus sphericus. In the medial wall the mouth of the vestibular aqueduct and the openings for the nerves coming from the internal auditory meatus are seen. The latter are called the maculae cribrosae. On the anterior wall of the vestibule is the large opening for the cochlea, and on the posterior wall the opening for the semicircular canals can be seen.

The *cochlea*, which represents the anterior part of the middle ear, consists of two parts: one is called the vestibular portion, the other the cochlear

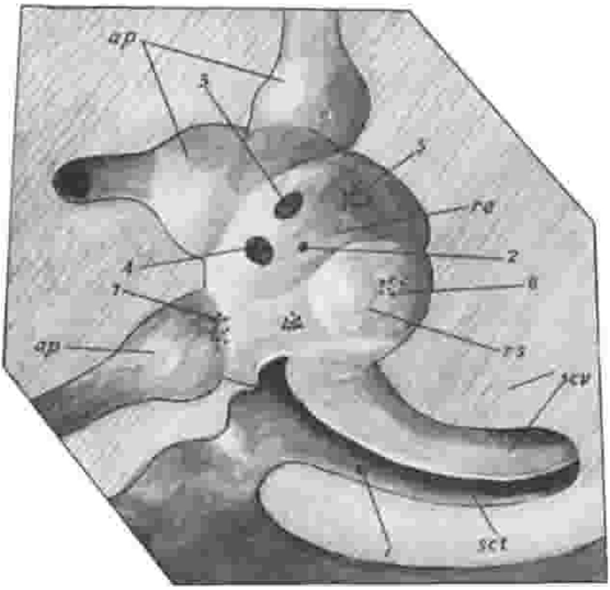

FIG. 4. DIAGRAMMATIC SECTION SHOWING MEDIAL WALL OF BONY LABYRINTH WITH TWO DEPRESSIONS

re = recessus ellipticus; *rs* = recessus sphericus; *sct* = scala tympani; *scv* = scala vestibuli; *ap* = ampullar ends of semicircular canals; *1* = cochlear aqueduct; *2* = vestibular aqueduct; *3* = horizontal canal; *4* = crus commune; *5* = macula cribrosa superior; *6* = macula cribrosa media; *7* = macula cribrosa inferior.

body. The latter shows two and a half turns, i.e., one basal whorl, one middle whorl, and one half whorl at the top. The blind end on top is called the cupula. The cochlea contains, on the inner bony wall, a bony septum following the same contour as the cochlea itself, and called the membrana spiralis ossea. This bony septum divides the space in the cochlea into two compartments. The lower compartment is called the scala tympani, and the upper the scala vestibuli. There is a large communication between the two scalae at the top of the cochlea, because of the absence of the bony membrane at this point; this passage is called the helicotrema. This communication between the perilymphatic fluid in the two scalae plays a part in the physiology of hearing.

Topographically, (FIG. 2), the cochlea is located between the internal auditory meatus and the carotic canal in such a way that its base looks toward the internal canal, while its top is directed toward the middle ear in the region of the tensor tympani muscle. The first turn of the cochlea corresponds with the promontorium, while the top whorl is 5½ to 6 mm. distant from the anterior rim of the oval window, separated by a thin bony partition from the tympanic cavity. There the cochlea is in close contact with the carotic canal. In opening the cochlear spaces in the course of a labyrinth operation, these anatomic relations should be borne in mind. In the region of the tympanal ostium of the eustachian tube, a thin bony plate lies between the anterior wall of the tube and the ascending portion of the carotid artery. Great care must also be given to the region below the promontorium. On opening the cochlea in this area, injury to the jugular bulb may occur.

The three *semicircular canals* represent the posterior part of the inner ear. Each canal consists of a crus with two limbs (external and internal limb for the horizontal canals, ascending and descending limb for the vertical canals). There are, further, two endings on each canal: one is the enlarged or ampullar end, the other the smooth or sinus end. The diameter of the bony canals is 1.2 to 1.3 mm., while the lengths of the canals differ: the inferior vertical canal is the longest, the horizontal the shortest, the ratio being 6:5:4.

Their relationships correspond to the three main dimensions of space. There is much confusion in the nomenclature applied to them. The horizontal canal is frequently called horizontal, lateral, external, or medial; the upper vertical canal is frequently spoken of as frontal, superior, or anterior; the lower vertical canal is often called sagittal, inferior, or posterior. There is also a difference between the nomenclature used by the anatomists and that of the otologists. The anatomists refer to the upper vertical canal as sagittal, whereas the otologists call it frontal. Similarly, the anatomists differ in naming the lower vertical canal. The reason for calling attention to the differences in nomenclature is because in different countries the terms are differently applied, and this causes much confusion in the textbooks and literature. Further, the frontal canal is not really in the frontal plane, nor is the sagittal canal really sagittal. For this reason, we prefer the simple designations of horizontal, superior vertical, and inferior vertical for these canals.

In order to study the topographic relationships of the semicircular canals, the use of an infant skull, which offers easy dissection of the inner ear, is most practical. In the newborn the labyrinthine capsule can easily be separated from the surrounding spongious bone of the pyramid. Such a skull shows best the normal and proper position of each canal. In such

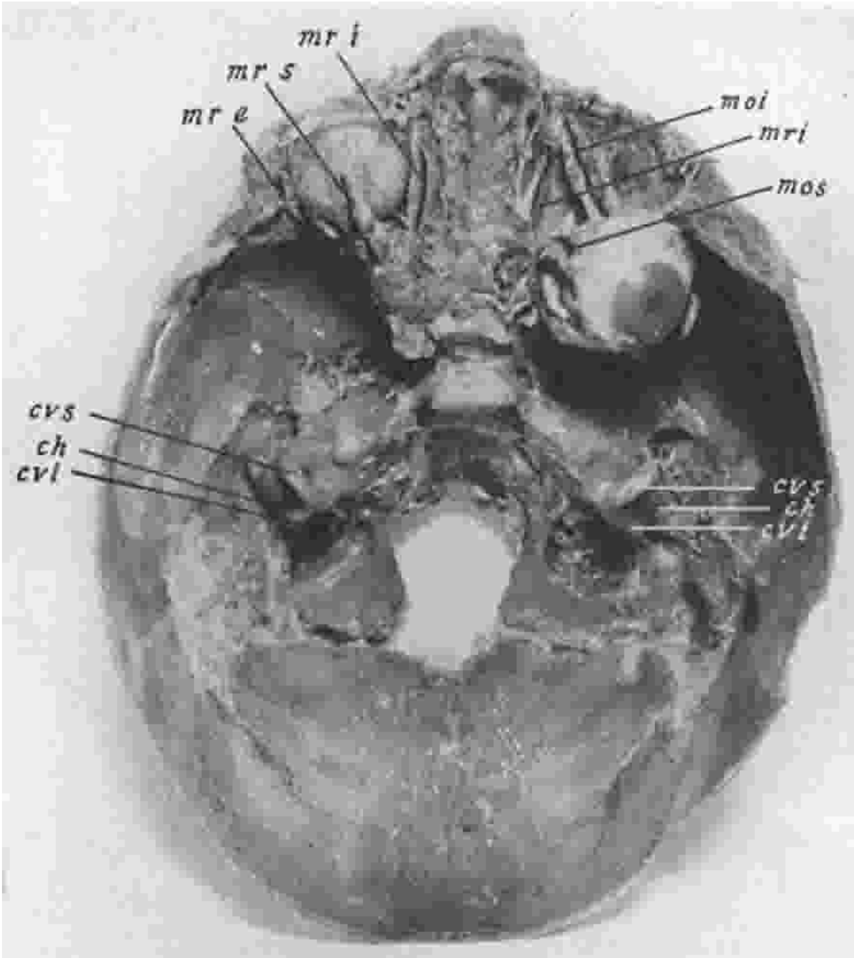

FIG. 5. PHOTOGRAPH OF BASE OF INFANT SKULL SHOWING EXPOSED SEMICIRCULAR CANALS AND EYE MUSCLES

For topographic studies, eye muscles are marked with black lines. Right eyeball is shown reflected. *ch* = canalis horizontalis; *cvs* = canalis verticalis superior; *cvi* = canalis verticalis inferior; *mr s* = musculus rectus superior; *mr i* = musculus rectus internus; *mr e* = musculus rectus externus; *mos* = musculus obliquus superior; *moi* = musculus obliquus inferior.

a specimen (FIG. 5), the inferior vertical canal forms a perfect 45° angle with the sagittal plane, with the open angle facing posteriorly; correspondingly, the superior vertical canal makes a similar 45° angle with the sagittal plane, but the open angle faces anteriorly. In the normal erect position of the head, the horizontal canal deviates 30° from the horizontal plane, in the backward direction. Furthermore, other interesting observations may be made when the two sides are compared. The superior vertical canal on the right side will be found to be parallel with the inferior canal on the left side; and the superior vertical canal on the left side will be found to be parallel with the inferior canal on the right side. Both horizontal canals will be approximately in the same plane.

Such an infant skull can further be used to show the relationship of the semicircular canals to the eye muscles. According to anatomic-physiologic studies made in man by Ohm, the topographic relations are as follows:

1. When both eyeballs are elevated 30° above the horizontal plane, the two horizontal semicircular canals are parallel with the rectus muscles (external and internal) on each side (Fig. 5).

2. The superior vertical canal of the left ear and the inferior vertical canal of the right correspond with the sagittal rectus muscles (superior and inferior) of the left eye and with the oblique muscles (superior and inferior) of the right eye (Fig. 5).

3. The superior vertical canal of the right ear and the inferior vertical canal of the left correspond with the sagittal rectus muscles of the right eye and the oblique muscles of the left.

Exact knowledge of the topographic relations of the three canals is very important for operation in the labyrinth and will therefore be discussed in detail.

The *horizontal canal* has its ampulla just above the oval window. The external limb lies anteriorly in the antrum; the internal or deeper limb lies in the bony pyramid, with a course downward and backward. The arc between the external and the internal limb lies 5 mm. behind the upper rim of the oval window.

The *superior vertical canal* has its ampulla right in front of the horizontal ampulla. The ascending limb lies externally, and climbs straight up to the eminentia arcuata, while the descending limb is near the posterior surface of the petrous bone. The arc between the two limbs forms the eminentia arcuata, which is a thin bony plate (1 mm. thick) separating the middle cranial fossa.

The *inferior vertical canal* has its ampulla on the floor of the vestibule, near the jugular bulb. The ascending limb runs backward along the posterior surface of the pyramid, while the descending limb shows a course to the vestibule and in the direction of the jugular bulb. In labyrinth operations care must be taken not to injure the jugular bulb while attempting to open this canal.