THE LARYNGOSCOPE.

VOL. XII. ST. LOUIS, MO., DECEMBER, 1902. No. 12.

ORIGINAL COMMUNICATIONS.

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THE NEIGHBORING PARTS OF THE MIDDLE EAR AND THEIR INFECTION.*

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The purpose of this paper is simply to renew your acquaintance with the anatomical surroundings of the middle ear. The lesson cannot be heard too often or learned too well. With our increasing observations and broadening experiences in cases of infection of the middle ear and its adnexa, the facts emphasize themselves more clearly on our minds of the absolute necessity of a most minute and perfect comprehension of the architecture of the temporal bone. Knowing this, we are in a position to interpret signs that are not always typical or classical of the so-called mastoid diseases, but with a less perfect understanding of the anatomy might be passed over lightly, or perhaps not recognized at all, when, in reality, we have going on some place or other in the temporal bone a process so destructive and virulent that at most any moment a life might be sacrificed.

With this knowledge perfected as far as possible, we know when to interfere surgically, where to go and how far to go. With a perfect knowledge of this subject, no otologist of to-day stops at a Wilde's incision in any case of mastoid disease aside from a periostitis.

A more comprehensive view of this subject might best be attained by looking at the bone at the very beginning of life, and thus following its growth through its various developments.

*Read at the Seventh Annual Meeting of the Western Ophthalmologic and Oto-Laryngologic Association, held at Chicago, April 10-11-12, 1902.

Morphologically, we have the ear bone made up of two parts, the auditory part, or so-called labyrinth, and the accessory parts, consisting of the auditory canal, tympanum, ossicles and Eustachian tube.

Figure I.—Ear of Human Embryo. (Minot's Embryology.)

Studying the drawing shown here, see Fig. I., (taken from Minot's Embryology), which represents a human embryo at three months, note that the tympanum is a small flattened cavity and a blind dilatation of the Eustachian tube. The auditory canal extends much below it, and its walls are in apposition, but soon begin to separate by the accumulation of epithelium and wax. Just above the tympanum lies the malleus and the other ossicles. Note that these lie outside of the cavity of the tympanum embedded in a mass of embryonic connective tissue, which gradually atrophies so that at or shortly after birth it has entirely disappeared; the tympanic cavity thus develops around the ossicles.

At birth ossification has advanced sufficiently so that we have an incomplete ring of bone, called tympanic ring, forming part of the outer wall of the tympanum. Within this ring is inserted the drum membrane. From it, as a starting point of development, we derive our bony external auditory canal. Growing outward, as it does, it replaces the fibro-cartilage that forms the canal at birth. The deficiency in the ring above is supplied and filled in by the growth of the horizontal portion of the squamosa, another separate point of development.

The mastoid portion of the temporal, practically absent at birth, although in some cases seen by me marked evidences of it were observed, develops from the petrous portion, and its anterior superior part from the vertical plate of the squamous.

The lines of union between these several parts are known as the squamo-mastoid and petro-squamous fissures, and they constitute very important structures and land-marks, as will be referred to later on.

Owing to the absence of the mastoid at this time, of course we can have no series of mastoid cells. However, one cell is constant; that is, the mastoid antrum. That exists already in prenatal life.

The mastoid is at first composed of fine cancellated bone tissue, and at two years of age it has established itself as a fairly well defined and distinct eminence, but no cells begin to appear until along the eighth or ninth year, with few exceptions, when the cancellated tissue gradually undergoes absorption, and in its place we have developed a series of more or less well formed cells. These cells communicate with one another and sprout, as it were, from the parent cell or antrum, gradually pushing themselves downward to the very tip, backward in some cases to the very margin of the parietal bone and sigmoid sinus, forward close to the wall of the external canal, inward beyond the plane of the digastric fossa, and upward in the squamous bone above the external meatus and even forward into the posterior root of the zygoma.

Scarcely too much thought can be given to the study of the development, character and location of these cells. A thorough knowledge of them gives you the key to the entire subject of mastoid disease.

By referring to the X-ray picture, (see Fig. II) these various points are beautifully demonstrated.

In order to obtain this picture, it was necessary for me to make

very thin sections of the dried specimen of the temporal bone. They were made with a Gigley saw, in the vertical plane, and about one-eighth inch thick. This exposed clearly every detail of the interior of the bone. The mastoid antrum and cells, and also the sigmoid and lateral sinuses were then painted with white lead, a piece of wire placed along the course of the facial nerve and the various sections were then glued together.

The external appearance of the bone is not always an indication of its interior. The removal of its outer plate does not always determine the conditions further within. Not any more so than the absence of swelling and redness of the overlying soft parts being a negative indication of destruction within the temporal; for you all know that we may have marked involvement of the entire mastoid process going on in some cases to great disintegration of tissue, and even to the formation of brain abscess or sinus complication, without any marked external manifestation.

Therefore, when armed with scalpel and chisel, we enter into the substance of the temporal bone, we should know what its make-up might be, where we must penetrate to find collections of pus, what we must avoid and the possible avenues by way infection might travel to neighboring parts.

Let us look at the subject from the side of the operator, i. e., from without inward. If you have determined to operate in a given case, the approved and accepted plan is to go straight for the antrum, excepting in cases of periostitis and in pus collections external to the bone from a dissection of the pus along the auditory canal from the middle ear. From this cell as a starting point, we commence our exposure of all the cells that appear to be, or we have reason to suspect may be implicated in the diseased process. Here is where a comprehensive knowledge of their exact location is of the utmost value. Those cells located in the lower portion of the mastoid process are easily exposed to view. They may be found as far down as the very tip of the process and extend as far back as the temporal suture, and virtually surround the sigmoid sinus.

Next, if necessary, work upward and forward to the cells often found well developed and located above the auditory canal, and even, in some cases that I have seen, in the posterior root of the zygoma.

Then, investigate the condition of that series of cells found internal and beyond the digastric fossa, and those posterior and behind the antrum.

Figure II. For description see opposite page.

It is to be remembered that the structure of the outer portion of the mastoid gives no definite information as to the structure of the bone further within. The outer half may be ebonized, and suddenly you appear in a large cavity, as seen in a case of mine. Or just the opposite, the outer part may be pneumatic and within it may be sclerosed or diploic. In other words, the bone may be made up as a whole of either diploic, pneumatic or sclerotic bone tissue; or it can be a combination of any two or all.

Again, the position of the more important structures adjacent to the antrum and its cells may differ in individuals to such an extent as to make anything like an extensive operation impossible, owing to the danger of injuring some one of them. The appearance of dense white bone within the field of operation will, in most every case, warn one of the immediate proximity of the Fallopiian canal, containing the facial nerve, and of the sigmoid sinus.

There are some specimens, and also cases on record where the sinus lies directly within the field of operation, so that exposure of the membranous canal is really unavoidable. It is true these cases are very few, but it is a contingency that must be looked for.

Broca, in almost 200 operations, failed to find such a condition and expresses himself by saying that he does not think that there is an antrum that cannot be entered without exposing the sinus.

The most dangerous point for finding such a condition lies directly back of the antrum. The nearer we approach the tip, the less likelihood of injuring the sinus.

This sinus, as you know, is the continuation of the lateral sinus, which makes the cycle of the intra-cranium from the Torcular herophili posteriorly along the attachment of the tentorium cerebelli to the base of the petrous bone. From here the sinus makes a sudden bend downward, forward and inward in an S-shaped manner, and then abruptly doubling upon itself, it leaves the intra-cranium by a large dilatation in the bone at the base known as the jugular fossa.

From the description of the course of these sinuses, it will readily be seen that the lateral sinus is in close contact with the contents of both the cerebellar and the posterior cerebral fossae, while the sigmoid sinus is in contact only with the cerebellar fossa. At the point, where the lateral sinus bends to form the sigmoid is to be seen an opening, usually quite large, this is the entrance of the mastoid vein, which penetrates the mastoid portion of the temporal to the outer surface.

Where the tentorium cerebelli is attached to the superior border of the petrous bone we have another very important sinus, the superior petrosal. This sinus empties into the sigmoid at a point near its origin, and has its source from the cavernous sinus towards the apex of the petrous bone. Thus it will be seen that it traverses the floor of the middle cerebral fossa above the middle ear and antrum.

Figure III.—Showing the relationship of Venous circulation to Cranial Sutures and Ear. (Hermann's Anatomy.)

The cavernous sinus is a short, although large and very important venous channel lying at the side of the sella turcica. It connects with its fellow on the opposite side by way of the circular and trans-

verse sinuses. The vessels tributary to it are the, 1 superior and inferior ophthalmic veins; 2 sphenoparietal sinus; 3 central retinal vein, and 4 inferior anterior cerebral vein.

It empties itself, as I have already mentioned, in one direction by way of the superior petrosal sinus. In another direction it empties into the internal jugular vein by way of the inferior petrosal sinus, and again into the anterior vertebral plexus by way of the basillar plexus. For an illustration of these various sinuses see Fig. III.

Aside from all these main routes mentioned in the case of the various sinuses, they have outlets in the form of minute veins communicating with the outside of the skull.

Figure IV.—The cavernous sinus and its contents. (Hermann's Anatomy.)

Lying within and passing through the cavernous sinus we have the following structures; the internal carotid artery with its sympathetic plexus, the third, fourth, sixth and ophthalmic nerves. The knowledge of all these things is of imperative importance to the otologist, for it is from the symptoms of an involvement of one or more of these sinuses complicating an ear disease that we determine just where the disease has reached and how it happened to get there. See Fig. IV.

In the very young subject, the antrum lies much higher and less posteriorly in relationship to the middle ear than we see it in more

advanced subjects. One may sometimes be misled as to its exact location in the infant, provided the temporal ridge, that guide usually selected for locating the upper limit in operating, overhangs the meatus and lies low. The size of the antrum in the child compares favorably with that of the adult. On this account, and because its depth is much less, as a rule, than in the adult, it is comparatively easy to locate.

Connecting the antrum on its anterior wall with the epitympanic cavity is a canal about 4 m.m. long called the aditus.

The middle fossa of the brain lies just above and in close relationship to the antrum, aditus and epitympanum. The plate of bone separating these cavities is called the tegmen. This structure is of vast importance on account of its often being the way infection enters the brain. Very frequently we find deficiencies in its development, and as a result we have only mucous membrane and dura separating the cavities of the ear from the brain.

On the inner wall of the antrum and aditus is the horizontal semi-circular canal. Passing along the floor of the aditus and in a vertical direction outward is the Fallopian canal containing the facial nerve. Lying just below and in a line with the aditus, but on the anterior wall of the tympanic cavity, is the opening of the Eustachian tube. The carotid canal lies to the median side of this tube in very close proximity—so close, in fact, that they often communicate by a dehiscence. This fact should be borne in mind in bougierring of the tube. Lying underneath the floor of the tympanic cavity is the jugular fossa. There are records of cases where communication has been established between these two cavities.

From this very brief survey of the anatomy of the neighboring parts of the middle ear, let us look at the manner and ways in which infection may reach them from this point. The manner in which involvement of such parts may take place, can be said to be by two ways: 1, by continuity of tissue, and 2, by way of blood and lymph channels, independent of, or associated with, but not dependent upon any previous ear trouble, as in case of syphilis and tuberculosis. It is only with the first that we are interested now.

Involvement by direct continuity of tissue may take place from carious destruction. This is probably the most frequent means of implication, especially in the adult, and almost always in chronic cases. In the acute forms and in children this is probably less so. Other means of involvement are numerous. It might take place by way of the numerous emissary and communicating blood chan-

nels, or by way of a lymph or nerve channel; and again, via a suture of dehiscence or a natural outlet.

In the case of the antrum and mastoid cells, the aditus furnishes the avenue through which the infection travels.

The petro-squamosal sinus, coursing along the superior surface of the petrous bone, is open in early life as a fissure, and at times exists as such in the adult, but otherwise is marked by many minute vessels. This, then, exposes the middle brain fossa to infection.

The squamo-mastoid fissure persists in children and occasionally so in the adult, and may open up a means of infection of the cerebellar fossa or sigmoid sinus.

Fig. V.—Showing the relationship of the brain to the cranial sutures. (Hermann's Anatomy.)

The labyrinth is in the way for involvement by way of the oval and round windows; the former opening into the vestibule, may carry the infection out at the internal auditory meatus into the cerebellar fossa; the latter, opening into the cochlea, which has venous intercourse with the inferior petrosal and jugular sinuses.

The lateral, sigmoid and superior petrosal sinuses, the jugular fossa, the temporo-maxillary vein and the venous system of the dura all have communication with the middle ear, and its cells by means of numerous little venous vessels.

The entrance of the chorda-tympani nerve from the Fallopian canal and its exit through the canal of Huguier in the Glaserian fissure offers another avenue for infection to follow.

Lastly, I would mention that the parotid gland and the lateral wall of the pharynx may become implicated in an infective process from the middle ear, owing to their anatomic relationship to the fissure of Glaseri.

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