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President—R. SCOTT STEVENSON, F.R.C.S.Ed.

Extensions of the Tympanic Cavity

By Prof. VICTOR LAMBERT

THE most cursory examination of the base of the skull of, say, a Lemur and a Homo reveals at once the striking fact that the bulla, which is such a conspicuous feature of the lemurine skull, is completely absent in Homo, but that in Homo the area previously occupied by the bulla is honeycombed with small air-containing spaces which we recognize as pneumatization. Professor F. Wood-Jones suggested to me that an examination of the temporal bones of the Primates might help to elucidate the underlying mystery of this change, particularly as it was felt that the structural changes must, as in all cases, be a reflection of changed functional need.

In the investigation it was decided not to consider the various cranial elements forming the tympanic cavity or their phylogenetic origin, particularly as this field had already been well covered by many previous writers. Consideration was given to the evolution of the ossicular chain, but as this was done from literature and not by original observation, it is not included in this paper.

When the lower vertebrates which were formerly wholly aquatic in their habits became even partially terrestrial, a new method of conducting sound waves to the ear was necessitated, and so the eustachian tube, the tympanic cavity, and the external auditory meatus were developed. It would seem that from the first inception of a mechanism to deal with airborne sound waves, there developed a resonance chamber intervening between the membrana tympani or its homologue and the internal ear, and that this resonance chamber was essentially a dilatation of the posterior end of the eustachian tube. This posterior dilatation we are accustomed to call the bulbus eustachii. In the primitive land-living vertebrates, it is a comparatively small cavity, the limits of which are defined by the area occupied by the membrana tympani on the one hand, and the immediate region of the fenestra ovalis and the fenestra rotunda on the other.

In the lowest of the marsupial mammals a marked advance from this condition is met with ; there is still the tympanic cavity of the lower vertebrates which is represented by what we term here the atrium, but in addition to this the cavity is enlarged by an apparently new dilatation of the bulbus eustachii. This is the cavity which in mammalian anatomy is referred to as the auditory

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bulla. The development of this added resonance chamber appears to be a necessity in all the lower animals regardless of their phylogenetic relations, and in the different phyla the chamber is formed by such varied cranial elements as the entotympanic, the petrous, the sphenoid and the squamosal.

In all these primitive mammals the internal carotid artery is a comparatively small vessel, greatly exceeded in size by the external carotid artery, but in the primitive mammals the large cranio-facial area derives its blood supply from the external carotid artery, whilst the smaller of the two vessels, the internal carotid artery, supplies the brain, which at this stage is relatively small. In the different mammalian types, the internal carotid artery enters the skull in a variety of ways. In the Primates alone does the site of entry eventually happen to coincide with the area from which the bulla is derived, but so long as the internal carotid artery remains small, there is no embarrassment to the bulla, but when the carotid artery increases in size, it eventually usurps the area occupied by the bulla.

Fig. 1 shows the bulla of Tarsius, which it will be seen greatly exceeds the size of the atrium proper, and the carotid canal is present as a thin tube of bone passing through the posterior margin of the bulla.

In Fig. 2, the Old World Monkey, we see the greatly increased internal carotid artery passing through the apex of the petrous bone, and no sign of bulla development can be recognized on the surface of the skull. The homologue of the bulla is now apparently nothing more than a pneumatized area in the petrous apex, which communicates in a variable way with the extremity of the tympanic tube. This condition of a variably pneumatized petrous apex is maintained in all the Old World Monkeys, Anthropoid Apes, and Man. In Man, the communication between the eustachian tube and pneumatic cells of

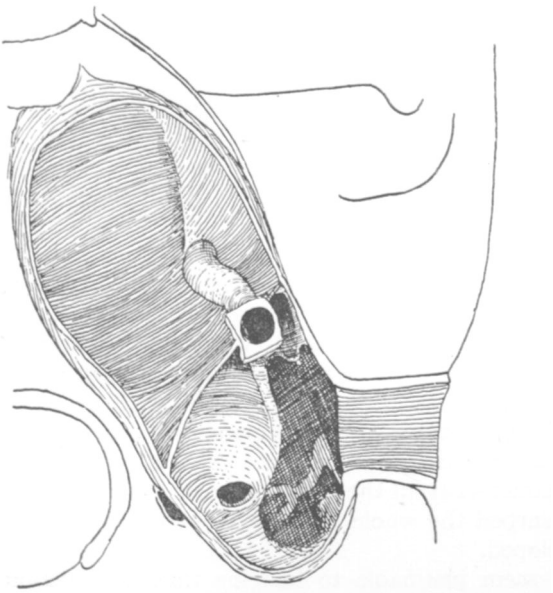


FIG. 1.—Left bulla of Tarsius opened from below.

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the petrous apex takes place in a variable manner. It is apparently normal in Man for some diverticula of the tube to be developed from its lower surface at its mesial extremity. These represent the " tubal cells " which were shown in the corrosion specimens of the middle ear by Siebermann, quoted in Poirier's book in 1912 (Poirier, P., and Charpy, A., *Traité d'anatomie humaine*, Paris, 2nd edit., v, 2).

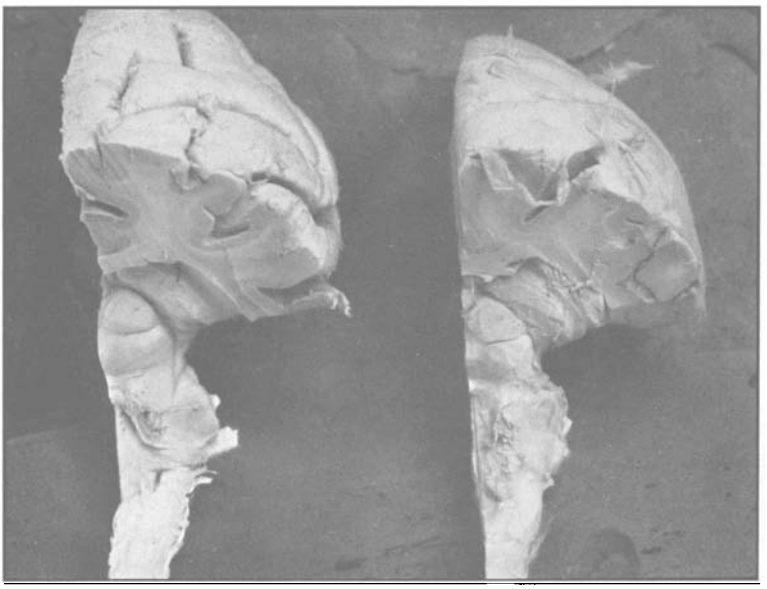


FIG. 2.
Under side of the right tympanic region in the skull of an adult Papio. The petrous apex has had its lower surface removed. The external auditory meatus has been removed and the atrium is exposed. The posterior portion of the temporal has been opened to display the pneumatization.

Fig. 3 graphically illustrates the effect of the ever-increasing size of the internal carotid artery on the bulla area. It is probable that the antagonism between the development of a large internal carotid artery and the formation of the bulla chamber in the area of bone that it invades is capable of a functional explanation. In the Primate series, the internal carotid artery is an ever-increasing vessel, because of the demands of an increased blood supply to an ever-increasing brain. In the final stages, when the typical development of the cortex characteristic of the higher Primates is achieved, the internal carotid artery has usurped the whole of the area in which the primitive mammalian bulla is developed.

It would seem justifiable to imagine that a reduction of the resonance chamber connected with the tympanic cavity and the enlargement of cortical

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(*a*) (*b*)

FIG. 4.

Right side of the mid-brain of (*a*) Platyrrhine and (*b*) Catarrhine monkey of similar size. The cerebellum and posterior part of the hemispheres have been removed to show the corpora quadrigemina. In the Platyrrhine, the inferior corpus quadrigeminum considerably exceeds the size of the superior body. In the Catarrhine, the inferior corpus quadrigeminum is relatively smaller and is about equal in size to the superior body.

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auditory areas might have been a harmonious process in the development of the Primates. Mere auditory acuity, as Cuvier postulated, is of the utmost importance as a life-saving mechanism in more primitive nocturnal animals, to which even the slightest sound is their principal warning. The cortical sense of this sound-receiving mechanism need not be, and in fact is not, at all extensive. The auditory sense organ of the lower animals may be described as a mechanism developed for a quantitative appreciation of sound waves, of which the cortical connotation need not necessarily be pondered. On the other hand, in the Primates with their ever-increasing cortical area devoted to the psychical appreciation of sound, the actual efficiency of the end-organ need not necessarily be so great ; indeed, the story that applies to other sense organs of the Primates seems to be true in the case of the ear. For survival importance, the cortical interpretation of any sensory impulse vastly outweighs the perfection of the sensory receptor.

Some slight anatomical evidence of this in the case of the ear may be obtained by contrasting the brains of the New and the Old World Monkeys (Fig. 4), for it is here seen that the part of the brain connected with subcortical reception of auditory impulses is the inferior corpus quadrigeminum, and it would be natural to suppose that this body might be better developed in animals that had an efficient area of cortical representation. In contrasting the inferior corpora quadrigemina of the New and the Old World Monkeys it is found that in the New World Monkeys, where the bulla development and epitympanic

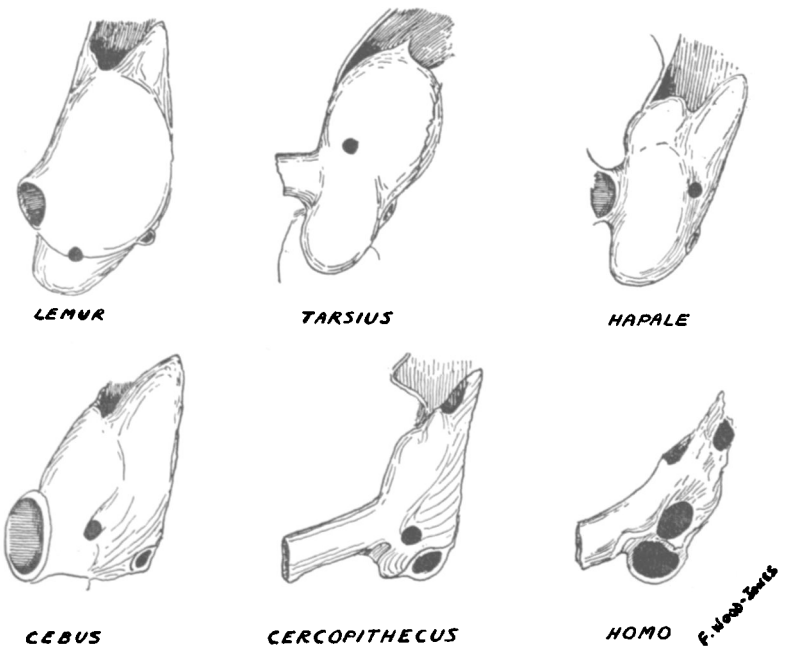


FIG. 3.

Right bulla region of a series of Primates to show the relations of the carotid artery, jugular vein, and eustachian tube to the bulla region.

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extensions are still present, the inferior corpora quadrigemina considerably exceed the superior bodies in size, whereas in the Old World Monkeys, where the bulla region and the posterior extensions are practically obsolete, the reverse is true.

Why the bulla area should be replaced by pneumatization is one of the unsolved problems in comparative anatomy, and this investigation has not helped to solve it, but it would appear that the bulla mechanism is rendered obsolete by the growth of the central critical faculty of the brain.

The reproductions are photographs of the original black-and-white drawings which Professor Wood-Jones was kind enough to make for me.

The Ætiology of Swimmers' Exostoses of the External Auditory Canals and of Associated Changes in Hearing (Résumé)

By W. STIRK ADAMS, F.R.C.S.

THIS enquiry was undertaken to ascertain whether the opinion held by English Otologists of the last century, particularly G. P. Field (1893), and later by Van Gilse (1938) and Belgraver (quoted by Van Gilse) of Leyden, that massive exostoses of the external auditory canals were the result of long-continued swimming was still valid; and if this was supported, to discover the causal factor in swimming producing these changes, and to ascertain the incidence of deafness in their presence, as an indication of possible associated exostoses in the middle ear.

During the past five years every patient in whom external canal exostoses have been observed in my practice has been asked for a history of swimming. The questionnaire included the family liability to deafness, the age at which swimming was learned, the number of years during which it was practised, either occasionally or regularly, in baths, river or sea. It included the swimming stroke used, the practice of diving or plunging, swimming under water, and the habit of immersing the head when taking hot or cold baths, and the use of a rubber head protector.

In all, 22 men and 6 women presented exostoses, and all gave a history of regular practice of swimming. The ages of the men ranged between 22 and 57, and they began to swim at between 5 and 14 years old, while their swimming history was from 6 to 41 years. The ages of the women ranged between 17 and 44. They had learned to swim at between 5 and 12 years old and their swimming history extended from 10 to 33 years.

In these 28 patients social deafness was only present in 6, and in 4 of these a family liability to deafness was recorded.

Of the swimming strokes used, the breast stroke predominated. Diving and swimming in fresh or salt water, either in the tropics or in England, appeared to have little influence on the size of the exostoses present.

In the course of this enquiry, however, other patients suffering from deafness who had no exostoses gave a swimming history, and it became evident that only a proportion of those exposed to similar risks developed these bony changes.

To estimate this proportion I examined in 1947 the ears of 18 boys aged 13 to 19 years, who were members of a public school swimming team, with a swimming history of from two to eight years. Of these, 14 showed evidence of

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exostoses, while 4 had normal canals. As a control, 11 school non-swimmers of the same age-group were examined, and of these only two showed deviations from the normal symmetry; one of them immersed his head in hot water baths; the other had no water history at all.

In assessing the ætiological factor in susceptible individuals the effect of hypertonic and hypotonic solutions was considered, and also the possibility of a surge of water in wide canals. I reached the conclusion that the stimulus of cold some 35° F. below body temperature is chiefly responsible. This view is supported by two other cases of exostoses in men who were not regular swimmers. One aged 64, with bilateral occluding exostoses, had immersed his head in a daily cold bath since boyhood; while the other, aged 68, had rolled his head under hot water in a daily bath all his life. He presented, on one side only, two minute exostoses external to the upper part of the tympanic ring.

Conclusions

(1) The enquiry confirmed the views of Field and Van Gilse that massive exostoses of the external auditory canals are the result of swimming.

(2) The ætiological factor is cold, though water itself, at higher temperatures, may produce some effect.

(3) Exostoses may be present in susceptible individuals after three years of regular swimming, the shortest period in this series being after two years' exposure, in a boy of 14.

(4) Insufficient evidence was available to assess the possibility of the presence of associated middle-ear exostoses as a cause of deafness in swimmers.

References

Field, G.P., 1893, Diseases of the Ear, London, Fourth Edition, p. 83.
Van Gilse, P.H.G., 1938, *Acta Oto-Laryng.*, xxvi, 343.

Mr. H. V. Forster said that his experience agreed with that of Mr. Adams that these cases were less commonly observed in the hospital clinic. He remembered well a number seen privately in the consulting room which included players of water polo and enthusiastic amateur swimmers.

He had occasionally noted hyperostoses in patients with chronic suppurative otitis media treated regularly at home with the syringe, but it was difficult to be certain that the treatment had been the cause of the bony changes in the external auditory canal.

Mr. N. A. Punt said that amongst the troops in Austria and North Italy nearly all the men were very keen swimmers, and amongst them was found a relatively large incidence of exostoses of the external auditory canals, in marked contrast with the rarity of such conditions among men who did not swim, such as the rural population of mid-Kent.

There might be some analogy with exostosis of the tibia occurring in cases of varicose ulcer, which present the sequence of skin irritation, periosteal irritation and exostosis.

Mr. Graham Brown thought that the association with exostosis of inflammation of the external auditory canal was a very real thing. A great number of

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people who went swimming got otitis externa, and he thought that the association of inflammation of the canal, the effect of wax, and of the water, together with infection, created a very favourable condition for irritation and inflammation of the bony meatus. This was seen particularly in tropical and subtropical regions where a great proportion of the population commonly bathed. In his view the great ætiological factor in the formation of exostosis was the inflammatory condition produced by water in the ear, whether fresh or salt, which in turn led to a periostitis and deposit of bone.

MR. R. R. SIMPSON said that he spent three years in Ceylon during the war where he had records of over 6,000 cases of otitis externa. Among the men there, who were accustomed to frequent bathing, otitis externa was extremely common and exostoses extremely rare.

MR. W. I. DAGGETT agreed with Mr. Simpson's experience after his own two years in the Mediterranean.

MR. STIRK ADAMS, in reply, said that in his own series the earliest sign of exostoses was encountered in a schoolboy who had been swimming regularly for two years, while most of these boys had been swimming regularly for at least three years, and others from four to eight years. In Van Gilse's series, exostoses were recognized after eight months' exposure to regular swimming and one year after continuous use of cold aural drops.

Demonstration of the Human Labyrinth and its Related Structures in Perspex

By OLIVER GRAY, M.B.E., B.A., M.B., Ch.B.

A BRIEF outline of the method of preparation was given, a full description of which will be found in the *Journal of Laryngology and Otology* for May, 1948. It was pointed out that this was based upon the pioneer work of the late Dr. A. A. Gray of Glasgow (father of Dr. Oliver Gray).

Monomeric methyl methacrylate, " the monomer ", is a liquid of the consistency of water which, under the influence of heat or ultraviolet light, becomes polymerized into a hard solid, " the polymer ". This latter substance is known as Perspex and is as clear as glass. After complete dehydration the portion of the temporal bone is placed in the liquid monomer which invades all the tissues *except* the dense bone. Gentle heat is then applied and the monomer " sets ". Eventually everything that is not bone becomes impregnated with solid Perspex. Now it so happens that Perspex is quite unaffected by strong hydrochloric acid, and when the whole is subsequently placed in the acid bath, the bone is dissolved away, gradually disclosing, with singular completeness and fidelity, the component structures of the ear. The photograph (Fig. 1) illustrates the results which can be achieved by this process.

Owing to the durable nature of the Perspex, the relationship of the delicate structures is permanently preserved in such a way that a precise study can be made of one of the most intricate parts of human anatomy and, with reasonable care, the specimens can be handled without fear of damage.

This new method may also help us in challenging the text-book descriptions, which are none too secure. For instance, the fact that the chorda tympani does

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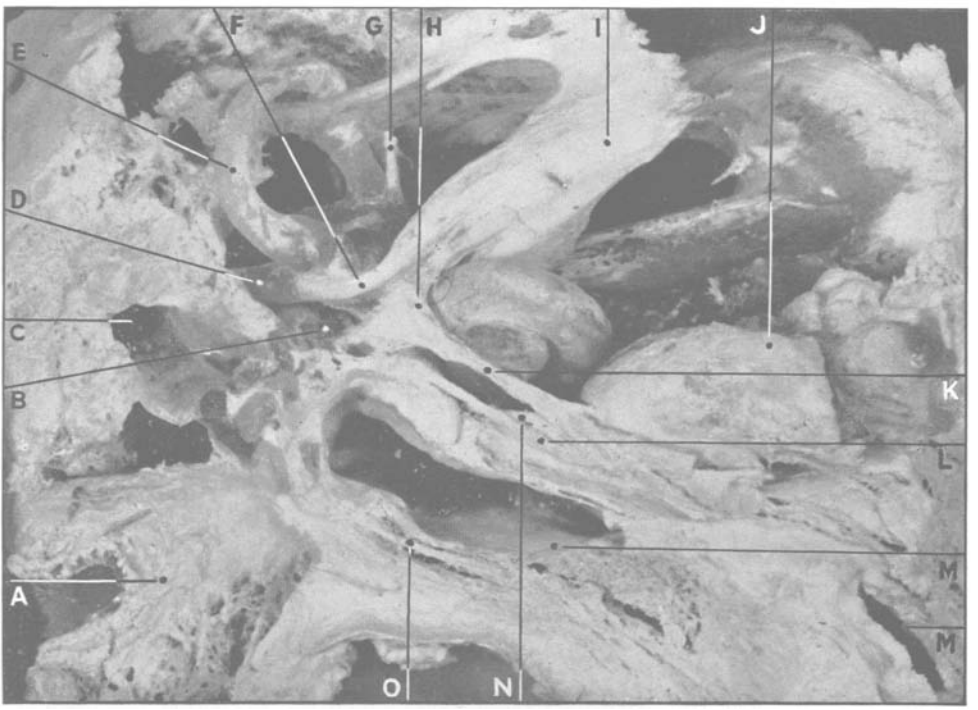


FIG. 1.

Photograph of right labyrinth (human) and related structures in polymerized methyl methacrylate (Perspex) after removal of the dense bone by hydrochloric acid. Viewed from above.

A. External auditory meatus.
B. Facial canal.
C. Mastoid antrum.
D. Lateral canal.
E. Superior canal.
F. Nerve to superior and lateral ampullae.
G. Aqueduct of the vestibule.
G. Geniculate ganglion.
I. Internal auditory meatus.
J. Carotid artery.
K. Great superficial petrosal nerve.
L. Lesser superficial petrosal nerve.
M. Eustachian tube.
N. Nerve from tympanic plexus.
O. Chorda tympani.

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not leave the skull through the petrotympanic fissure (Gray, *Atlas of Otology*) is shown clearly in the preparations obtained in this way.

At the meeting of the Section, in the morning, lantern slides were shown, and throughout the day an opportunity was given of viewing the specimens.

REFERENCES

GRAY, A. A., 1924, *Atlas of Otology*, Glasgow.

——— 1948, "New Method of Demonstrating the Labyrinth", *J. Laryng. and Otol.*, lxii, 308.

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