A NOTE ON TURBINAL AND SINUS FUNCTION.

By James Adam, M.D.,
Aural Surgeon, Glasgow Royal Infirmary Dispensary.

To the views here stated I have given expression as occasion offered during the last few years; they are based on many observations and experiments, which, though not so complete as could be wished, yet seem sufficiently corroborative to justify publication. The paper deals only with what may, for short, be called the hygrothermic function of the nose, the warming and moistening of the inspired air.

The contention is that the accessory sinuses have a more, the turbinals a less, important share in this function than is usually assigned them. It is not contended that the sinuses have no value as enriching the resonance of the voice or lightening the structure while conserving the strength of the skull; but these seem subsidiary to their respiratory value. In detail the thesis is as follows:

(1) The whole mucous membrane of the respiratory tract from nostrils to bronchioles is hygrothermic and the chief agent to this end.

(2) The whole nasal mucous membrane is specially concerned in this function.

(3) The sinuses are accessory not only anatomically but also physiologically, more especially during the forced respiration of exertion.

(4) The turbinals, while important accessories to the hygrothermic function, especially during quiet respiration, are probably quite as much directional and regulatory in their action, *i. e.* they help to regulate the amount and direction of the air current going to and drawn from the sinuses and respond to the amount required for the lungs.

The current view is that the turbinals are the chief agent in warming and moistening the inspired air; that the sinuses are in man, a microsmatic mammal, the anatomical remnant no longer physiologically useful, of a more complex system found in macrosmatic mammals. In the latter the olfactory nerve has a much wider distribution over the sinuses which thus subserve the sense of smell. This statement seems to me correct in what it affirms, but wrong if it denies their hygrothermic usefulness to respiration, or if it affirms that all the sinuses in macrosmatic mammals subserve

https://doi.org/10.1017/S1755146300186512 Published online by Cambridge University Press

olfaction. This, however, after a full consideration of the literature and of the whole question of the function of the sinuses, is the view to which, for instance, Zarniko comes: but still, he admits that it is rather striking that the main inspiratory current goes past the fore end and not over the body of the inferior turbinal, the chief erectile body in the nose.

We have to consider—

(1) The behaviour of the turbinals during quiet and during forced respiration.

(2) The air-path during the same.

(3) The position and structure of the sinuses, and also the position of their orifices relatively to (1) and (2).

(1) *Behaviour of the Turbinals.*—After quiet respiration in a warm room has lasted some time they are found to be full. Some of my medical friends frequently complain of the nose being blocked on entering a warm room after having breathed freely out of doors. On current theory and if the hygrothermic action of the turbinals is directly as their fulness, this is the reverse of what should be. If, now, a nasal speculum be allowed to remain in the nostril for a minute or two they will be seen to shrink. Why? And above all, why, if the air at room temperature, entering freely the dilated nostril, is to be warmed to body temperature? As the nostrils dilate on exertion it struck me this might be a reflex due to the dilatation. A lad was sent on a smart walk; his turbinals, previously full, shrank decidedly. Those of a man after a run shrank even more; those of a sprinter, after a very fast sprint, were drawn tight to the bone as if adrenalised. Special attention was paid to the middle turbinal of the sprinter; its anterior end was quite contracted, and the entrance to the semilunar hiatus, previously a tiny slit, was now frankly opened. Mouth-breathing has nothing to do with this action, as the exercises were done with mouth shut. These observations have been repeated on different subjects at different temperatures and the effects observed both in and out of doors, always with the same result—that is, the turbinals, if hygrothermic, are least in evidence when most wanted. If, however, the sinuses are important aids in warming the air, we can understand the turbinals shrinking to allow of free passage of air to them, and therefore from them. Similarly, the reflex collapse of turbinals on dilatation of nostrils might be purely or partly a temperature response as distinguished from an exertion one, to allow of intermingling of warmed sinus air with the colder external current. Various experiments were

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tried with less decisive, but on the whole similar, results, namely, some shrinking on exposure to reduced temperature. And again, as regards moisture, a hot dry atmosphere was found to shrink the turbinals more than a hot moist one, the reverse of what we should expect if the turbinals are the moistening agents. About these effects of moisture and temperature, as they are difficult to determine and as there are often complicating circumstances, I wish to be less emphatic; what is certain is that the effect of exertion always dominates that of heat or temperature alone.

(2) *The Air-path.*—Observations have been made by allowing the patient to inhale aristol, which is a very light powder, and then noting its route, with or without the subsequent application of cocaine and adrenalin. During quiet inspiration the path is that mentioned by Paulsen, mainly past the fore end of the lower turbinal and passing between the middle turbinal and the septum to the nasal roof and down in front of the sphenoid. When the current reaches the anterior end of the middle turbinal and the sphenoid face eddies must be formed, as Franke has proved and as the layer of aristol on the middle turbinal shows; but I find that when the current reaches this point it forks, a smaller portion going by the semilunar hiatus.[1] As to the amount of air going by these two routes much depends on the shape of the septum and of the middle turbinal. A septum with a low bulge outwards below a middle turbinal bulging inwards makes the semilunar the main path; but usually, the main path is the olfactory one between middle turbinal and septum. And we should expect this; for during quiet respiration we are always smelling though we are not always noticing. During exertion matters are different; smell is subsidiary; and in the heavily breathing sprinter the aristol was found thickly plastered round the inlet to the semilunar hiatus; in other words, right round the inlet to the sinuses as well as on adjacent parts of turbinal and septum; in fact, during such respiration I have also seen the lower meatus lined with powder, showing that the whole nasal surface is brought into action during forced respiration.

The main air-path, especially during quiet respiration, is the septal or olfactory one; the external or semilunar path comes more into play during the forced respiration of exertion. Indeed, both paths are then much more open. It has been stated (Kayser) that absence of the inferior turbinal makes no difference to the air-path,

[1] I ought to point out that an eddy will form more readily before the bluff end of the middle turbinal of quiet inspiration than when the turbinal is shrunk to a sharp edge by exertion.

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but this is only partially true. In quiet respiration most of the powder is deposited at the same sites as in a normal nose, but it is also found lower than usual. If, however, a patient without lower turbinal sniffs aristol, even slightly, a thick coat of it will be found along the septum parallel with the turbinal site, and some of it on the nasal floor; normally it would all go higher up. This was demonstrated in a case where one lower turbinal had been removed by another surgeon; the different deposition of powder in the two nostrils showed that the main air-path, was altered as indicated. It is probably this alteration of the air-path not the mere absence of turbinal, that sets up pharyngitis; except in quiet respiration the air is no longer directed properly through the upper reaches of the nose and past the sinuses.

The expiratory air-path is stated to be the same as the inspiratory (Paulsen). This seems only partially true. The vertical choanæ, in contrast to the horizontal nostrils, help to direct the main inspiratory blast parallel with, instead of athwart the turbinals, so that the chief current is above and below the inferior turbinal. This can be seen with some difficulty by examining the nose of a smoker who is exhaling very gently through his nose; and it is a well-known fact that it is easier to blow out of the nose mucus or pus or a pledget of wool when that is in the inferior meatus than when it is higher up. But neither during inspiration nor expiration is the air in any part of the nasal cavity devoid of movement (Paulsen).

(3) *The Sinuses and their Orifices.*—They are in two groups, the ethmoid being shared between them. The posterior ethmoidal cells and the sphenoidal sinus open on the olfactory or septal air-path; the anterior ethmoid cells, frontal sinus and antrum open on the external or semilunar route. The orifices of all open directly on the inspiratory air-paths and are therefore readily ventilated during breathing, and that is why the sphenoidal and antral ostia are in the upper parts of those cavities, well placed, not for drainage, but to allow of warm air readily rising out of them. The ventilation of these cavities will be after the fashion of a Sprengel pump; the main current streaming past will take on some of the sinus air with it, which will be instantly replaced by succeeding air from the nasal cavity. The direction of the main expiratory current being in the lower reaches of the nose where none of the sinus ostia open, sinus ventilation will be more thorough during inspiration than during expiration, so that the sinus air will mostly have the interval between the end of one inspiration

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and the beginning of the next to get warmed. Franke noted that an eddy of smoke-laden air entered the sphenoidal sinus during inspiration but was not disturbed during expiration; none, however, entered the frontal or maxillary. After douching an antrum in the usual way by puncture through the lower nasal wall I joined a T-tube by rubber connections to the cannula, a gas tap and a Bunsen burner, and lit the last white. It is very difficult to get a flame still enough for accurate observation; but so far as I could judge the flame was unaffected by quiet respiration; this we should expect if the inspiratory path in quiet respiration is mainly septal. During forced respiration the flame seemed to move up and down; when the patient blew through both nostrils the movement was very decided; when he closed the sound nostril and blew through the other the flame gave a sudden jump, then went out (it was away from direct blast, a yard behind his head). The current is probably not usually so strong as this, for the extinction of the flame happened only once; where there was blocking of middle meatus the flame was unaffected. But there seems sufficient proof that during strong respiration such as occurs on exertion the sinuses are all frankly drawn upon, as they certainly are during sniffing and snorting. With regard to Franke's observation that only the sphenoidal sinus was seen to be entered by a whorl of smoke-laden air, I have to suggest that for reasons above stated this is the only sinus we should expect to be so entered during quiet inspiration, because then the main air-path is on the septal side of the middle turbinal; the shrinking of the turbinals no exertion allows the larger external sinuses to be drawn upon. The capacity of the sinuses has been estimated as twice that of the nasal cavities proper—probably a low estimate, so that they are capable of storing a fair volume of warm air. They are well placed in the skull for warmth, having a lining membrane capable of giving off a certain amount of moisture, and, as Tunis has pointed out in a paper published while this is being written, their orifices are surrounded by mucous glands which must contribute to this effect. The ventilation of the sinuses will take place the more easily because of the expansion of the air warmed in them rising to meet the cooler nasal air.

When we consider, therefore, the capacity of the sinuses, their character, their position, their relation to the air-paths, and also the shrinking of the turbinals on exertion, it is difficult to avoid the conclusion that the sinuses are chambers for storing reserves of warm, moist air to be instantly mingled with the inspiratory

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air, especially on exertion. In other words, they are accessory to the hygrothermic function of the nose as a whole. And when one further considers the accessory cavities of a horse, an animal whose nose is designed to deal with the respiration of exertion, the idea that these cavities merely subserve olfaction, or that in man they are mere structural padding or evolutionary remnants, is unthinkable. Such merely structural cavities are seen round the frontal boss of the ox in connection with the frontal sinus; but they are obviously for strengthening the frontal plate, and different from the adjoining respiratory sinuses. The ethmoid might be regarded from its spongy structure as mere scaffolding, like the bulk of the mastoid cells, but it is a curious fact that it is shared between the two air-paths and the two groups of sinuses, and bears some resemblance to the extraordinary spongy structures which nearly fill the bulk of the nose of the seal, and which are turbinals. This is one of the few mammals that Turner classifies with man and apes as microsmatic; it has no accessory sinuses. To the question of the comparative anatomy and physiology of the sinuses I hope to return in a future paper, but would remark here that the ethmoid probably helps to moisten the air.

The view thus advanced is somewhat similar to that of Luschka and H. Meyer, but brings the sinuses in more direct relationship with the respiration of exertion. Against those authorities most critics urge that the orifices are too small to allow of the sinuses being of more than very subsidiary use; but that interchange of air between these and the nasal cavities proper is pretty constant any one will believe who, travelling alone in a railway "smoker," watches the course of the smoke if he shuts all the openings except one window partially. This view also differs from that of Braune and Clasen, who would limit the usefulness of the sinuses to the times when there is a very decided negative pressure, as during sniffing, the nostril being more or less closed.

If the present contention be correct certain interesting inferences follow. The ablation of the sinuses cannot be regarded as a triumph of surgery. We should expect a pharyngitis then to arise; and, for the same reason, after ablation of the inferior turbinal. Also, the effect of exercise on the turbinals points to one important element in the treatment of what is called vaso-motor rhinitis, apart altogether from the beneficial effect which exercise has on the elimination of the toxins apt to be present in the blood in this condition. Finally, of the mastoid cells the antrum alone is constant; its function is unknown; may it not be an accessory cavity

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to the tympanum, so that colder air coming up the Eustachian tube would be immediately mixed with warmer air from the antrum? The tympanic orifice of the tube points toward the aditus, and, although the ossicles come between, the incoming air will go toward the wall on which opens the aditus. Every time we perform Valsalva's experiment the tympanic membrane goes outward and warm air must necessarily be sucked out of the antrum.

References.

For the German references I am indebted to Zarniko's "Die Krankheiten der Nase" and to Heymann's "Handbuch der Laryngology und Rhinology." Turner's paper on "The Convolutions of the Brain" appeared in the *Transactions of the Tenth International Medical Congress, Berlin*, 1890. Tunis, "Inflammation of the Sinus Maxillaris," the *Laryngoscope*, October, 1910, p. 931.

OTOSCLEROSIS.[1]

By Dr. Gustave Brühl (Berlin).

(Abridged translation by Dan McKenzie.)

Of recent years it has been generally agreed that the deafness characteristic of otosclerosis is the result of an osseous ankylosis of the stapes in the oval window, the middle ear in other respects being free from abnormality. With regard to the ætiology of the disease, however, there is still much difference of opinion. Questions have been asked as to the original seat in the bone of the lesion which induces the ankylosis. Is it to be found in the periosteum or in the capsule of the labyrinth? And if in the latter, in which layer of the bone, the internal or the external, does it occur?

All the agencies with which we are acquainted as causing bone disease in general have, at one time or another, been looked upon as being of importance in the production of otosclerosis. But none of these assumptions have satisfied the requirements.

Quite recently, indeed, doubts have actually been thrown upon the significance of the ankylosis of the stapes itself, and the classical view which looks upon the fixation of that ossicle as the *causa causans* of the symptoms of otosclerosis has been submitted to searching criticism. The grounds for this criticism lie in the fact

[1] From *Les Archives Internationales de Laryngologie, etc.*, January–February, 1911, p. 1. We desire to express our indebtedness to the editor of that journal for kindly permitting us to use the blocks of the diagrams illustrating the article.

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