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An Address

ON

KOCH'S DISCOVERY OF THE TUBERCLE BACILLUS

SOME OF ITS IMPLICATIONS AND RESULTS*

BY

SIR ROBERT PHILIP, M.D., LL.D.

PROFESSOR OF TUBERCULOSIS, UNIVERSITY OF EDINBURGH;
PHYSICIAN CONSULTANT, EDINBURGH ROYAL INFIRMARY

Robert Koch was born on December 11th, 1843, at Clausthal among the Harz Mountains, the third child of a family of thirteen. His father was a mining official. The lad passed from the local gymnasium to the neighbouring university at Göttingen, where, after working at mathematics and physics, he turned to medicine. As an undergraduate he assisted Henle in the pathological museum. He took his M.D. in January, 1866. After gaining experience in hospital at Hamburg and in general practice near Hanover and in Posen, he did Army medical service during the Franco-Prussian war. Thereafter he went to Wolstein as district physician in Bomst, Polish Prussia.

EARLIEST INVESTIGATIONS

In this little provincial town of Bomst, without the facilities of a university laboratory, Koch began observations on his own account. In his modest home a portion of the consulting room was curtained off so that, in the intervals between seeing patients, he might do microscopical work and, with some help from the local apothecary, seek answers to the questions which were stirring in his mind. He quickly realized the insufficiency of the existing microscope, and made suggestions to Professor Abbé and the firm of Zeiss with a view to its improvement. He investigated micro-organisms by means of staining methods and cultures to such purpose that, in April, 1876, he was able to write to the botanist, Ferdinand Cohn of Breslau, that in his study of the anthrax bacillus he had found the spores of the bacillus which, from analogy with other bacilli, Cohn had predicated. At the Botanical Institute, Breslau, to an audience which, in addition to Cohn, included three distinguished men—namely, Cohnheim, Weigert, and Traube, Koch demonstrated the development of spores within the *Bacillus anthracis*, their liberation from the bacillus, and the sprouting of the bacillus from the spore, the occurrence of spore formation in anthracic blood, and the production of anthrax in mice and rabbits by inoculation of the bacilli and spores. In 1876 he published his first classic paper on the aetiology of anthrax, based on a study of the life-history of the bacillus. Following this, in 1878, came a like important paper on the aetiology of wound infections.

* Delivered to the Osler Club, March 24th, 1932.

I mention these publications especially because they embody the results of two of Koch's earliest investigations, during the course of which it was necessary for him, not only to envisage his goal, but to cut every step for himself in a strange and almost pathless country. At every turn means had to be discovered to get round all sorts of difficulties and to follow the delicate thread which scientific intuition assured him would guide him aright. These early researches yielded results of first-class importance, and at the same time led to the discovery and elaboration of methods which gradually gave shape to the science of bacteriology, of which, prior to Koch's time, the foundations had been laid by Pasteur, Lister, and others. On the present occasion it would be out of place to say more regarding the vast aetiological harvest which bacteriology has reaped, and the reconception of the problems of disease which has resulted therefrom. Accordingly, *revenons à nos moutons!*

THE INFECTIVE THEORY

It was characteristic of Koch's mental make-up that his thought moved instinctively towards important issues—problems with many facets and large implications. This impelled him to the study of infection generally and, among infective conditions, particularly those of wide or universal distribution, such as wound infection, cholera, and malaria. That breadth of outlook led him to the investigation of tuberculosis. His big sweep of the subject is strikingly attested in the second and third paragraphs with which his classic monograph of March 24th, 1882, opens:

"Wenn die Zahl der Opfer, welche eine Krankheit fordert, als Mass-stab für ihre Bedeutung zu gelten hat, dann müssen alle Krankheiten, namentlich aber die gefürchtetsten Infektionskrankheiten, Pest, Cholera, etc., weit hinter der Tuberkulose zurückstehen. Die Statistik lehrt, dass 1/7 aller Menschen an Tuberkulose stirbt und dass, wenn nur die mittleren produktiven Altersklassen in Betracht kommen, die Tuberkulose ein Drittel derselben und oft mehr dahintrifft. Die öffentliche Gesundheitspflege hat also Grund genug, ihre Aufmerksamkeit einer so mörderischen Krankheit zu widmen, ganz abgesehen davon, dass noch andere Verhältnisse, von denen nur die Beziehungen der Tuberkulose zur Perlsucht erwähnt werden sollen, das Interesse der Gesundheitspflege in Anspruch nehmen.

Da es nun zu den Aufgaben des Gesundheitsamtes gehört, die Infektionskrankheiten vom Standpunkte der Gesundheitspflege aus, also in erster Linie in bezug auf ihre Ätiologie, zum Gegenstand von Ermittlungsarbeiten zu machen, so erschien es als eine dringende Pflicht, vor allem über die Tuberkulose eingehende Untersuchungen anzustellen."

Tuberculosis had been observed as a more or less definite disease from very early times. The evidence of its occurrence in ancient Egypt is incontrovertible, and throughout succeeding ages it was recognized in every civilized land. Yet its nosological relationships were misinterpreted for the most part. Here and there—notably among the Latin peoples—the conception of its infectivity emerged and resulted in the enactment of special laws and regulations in Italy and Spain. How little this Latin conception

permeated opinion in other countries may be gathered from the following annotation from the *Lancet* of March 9th, 1867, under the heading of "Death fees in foreign hotels":

"It seems that the Italians have most conveniently imbibed the notion that consumption is contagious and, should unhappily a phthisical patient die in an hotel, the bill but too often contains the singular item—'Indemnité pour réfaction des meubles et de la chambre occupée par le défunt, £100 sterling.' . . . The ground," continues the critic, "upon which such a charge, the most exorbitant of any that has been manufactured for many a long day, rests is utterly untenable, and, of course, the demand should at once be repudiated. At the same time a little care is needed to prevent surprise, for in those cases in which a house or an apartment is taken by agreement for any length of time, the legal document which binds the contract may contain a clause to the effect that the tenant is expected to pay the extortionate sum which we have named, in case of death occurring from consumption, and we notice the matter that the profession may put clients on their guard."

While the infectiousness of tuberculosis was suspected by many, the first instalment of actual proof was presented in the observations of Klencke (1843), who induced tuberculosis in rabbits by inoculation (intravenous) with tuberculous material from human source. These limited observations were followed by the authoritative communication of Villemin (1865) to the Académie de Médecine of Paris, in which he tabled the results of prolonged research, and demonstrated the infective character of tuberculous material obtained from man and cattle. Complete as the demonstration might seem to be, its validity was not universally admitted. In the discussion which supervened, Villemin's thesis received effective support from Cohnheim and Salomonsen, who, by a series of observations, using the anterior chamber of the rabbit's eye as the site of inoculation, proved conclusively that tuberculous material from different sources owed their infectiveness to one and the same specific contagion. It is at this point that Robert Koch enters the scene.

Basing his research on the infectivity of tuberculosis, as demonstrated by Villemin, Cohnheim, Salomonsen, Baumgarten, and others, Koch's genius enabled him to track and pinion the tubercle bacillus with superb nicety. In claiming the acceptance of the bacillus as the *causa peccans*, he defined—in keeping with the teaching of his master, Henle—the postulates essential to such a claim, and, by a record of brilliant experiment, proved beyond cavil that these postulates were satisfied by the bacillus. His comprehensive vision of the problem of tuberculosis, and his elaboration of one after another method at successive stages in the course of their solution, have crowned him one of the creators of the science of medicine.

PROFESSIONAL APATHY TOWARDS IT

The present generation of doctors can hardly imagine the blurred and faulty aetiological conceptions which, fifty years ago, were in vogue regarding tuberculosis. It so chanced that the announcement of Koch's discovery (1882) coincided with my graduation in medicine. As with other students up to that date, my training had been based on the pre-bacillary conception of Virchow, Niemeyer, Williams, and other authorities of those days. The suddenness of the switch to the bacillary view, and its import, had, in my own experience, profound consequences. Work in a different field was interrupted and interest was vividly aroused. I am happy to have this opportunity of rendering homage to the man of genius who impelled me to the study of the portentous questions opened up by his discovery—questions the fascination of which has continued uninterruptedly throughout the past fifty years.

Nor is it easy for the student of tuberculosis to-day to visualize the attitude of apathy that prevailed at the

date of Koch's discovery. One illustration will suffice. On returning to Edinburgh in 1883 and indicating my purpose to devote attention especially to the subject of tuberculosis, the remark of the honoured professor of medicine was: "Don't think of such a thing. Phthisis is worn to a thin thread. The subject is exhausted." What a contrast to the vast and ever-growing mass of record and literature which has emerged in the interval! The pages of the special journals concerned with tuberculosis (British, American, French, German, *et hoc genus omne*) illustrate how things have changed, and how formidable is the attempt to keep abreast of the infinitely varying lines of investigation, each one of which is referable to the fundamental fact reported to the Physiologische Gesellschaft zu Berlin on March 24th, 1882.

It was at 7 o'clock on a cheerless, damp evening that the Society assembled in the reading room of the recently opened Physiological Institute under the presidency of Professor du Bois-Reymond, the director of the Institute. The company, some thirty-six in all, included, in addition to the chairman, Helmholtz, Frerichs and his pupil Ehrlich, and Loeffler. It was a small group of trained scientists that listened to Koch's maiden speech in Berlin. The theme and the occasion were alike momentous. Eye-witnesses have told of some nervousness in Koch's opening words, and the precise and impressive character of every phrase. Each statement was supported by abundant, convincing evidence—macroscopic and microscopic. His closing sentence was followed by a moment or two of tense silence, to be succeeded presently by a fervid outburst of applause and congratulation. If the company was notable—the Physiological Society of Berlin—the occasion was little less remarkable by reason of those who were absent, notably Virchow, and likewise the then champions in medicine and surgery. For most of them the *volte-face* from the deeply rooted principles of cellular pathology and post-mortem findings was too abrupt. Their range of accommodation was too limited. "Simple nonsense" some declared: "Utter humbug"!

KOCH'S EVIDENCE PRESENTED

The classic monograph, "Die Ätiologie der Tuberkulose," occupies less than eighteen pages in Koch's *Gesammelte Werke*. It constitutes an amazing record. The simplicity and directness of statement are impressive. There is no beating about the bush. The essential elements of the problem are marshalled with unsurpassable clarity and completeness.

Almost before one is aware there commences the succession of infrangible links in the chain of evidence forged individually and collectively by the master mind. The paper remains for all time a model of scientific statement. The tubercle bacillus was identified in every variety of tuberculous product, human and animal, and was separated from every other organism. It was reproduced in pure culture outside the body. The pure culture, when transferred to animals, produced tuberculosis, and from the tuberculosis so produced the bacillus was recoverable. One of the greatest advances in medicine recorded in one of the most concise documents of medical literature! Within the compass of these eighteen pages is unfolded the solution of the enigma of the ages.

"Alle diese Tatsachen zusammen genommen berechtigen zu dem Ausspruch, dass die in den tuberkulösen Substanzen vorkommenden Bazillen nicht nur Begleiter des tuberkulösen Prozesses, sondern die Ursache desselben sind, und dass wir in den Bazillen das eigentliche Tuberkelvirus vor uns haben."

Damit ist auch die Möglichkeit gegeben, die Grenzen der unter Tuberkulose zu verstehenden Krankheit zu ziehen, was bisher nicht mit Sicherheit geschehen konnte. Es fehlte an einem bestimmten Kriterium für die Tuberkulose, und der eine rechnete dazu Miliartuberkulose, Phthisis, Skrofulose, Pelsucht, etc., ein anderer hielt vielleicht mit ebenso viel

Recht alle diese Krankheitsprozesse für different. In Zukunft wird es nicht schwierig sein zu entscheiden, was tuberkulös und was nicht tuberkulös ist. Nicht der eigentümliche Bau des Tuberkels, nicht seine Gefässlosigkeit, nicht das Vorhandensein von Riesenzellen wird den Ausschlag geben, sondern der Nachweis der Tuberkelbazillen."

To the original communications (1882-4) very little of essential character has had to be added. They have remained the foundation on which has rested all subsequent research. The implications of the record were very wide. Koch's television was astonishing. The trend of subsequent investigation was anticipated. The original monograph of 1882 contains in embryo the ampler knowledge which we enjoy to-day through the countless observations of half a century.

It may be convenient at this stage to link with the original monograph certain points from Koch's subsequent researches. Let me cite first the illuminating observations recorded by him in 1891 (*Deut. med. Woch.*, 1891, 17, 101) and usually referred to as the "phenomenon of Koch." These went to show that when a guinea-pig, already infected four to six weeks previously, is subjected to fresh inoculation, the course of events is entirely different from that following the first inoculation. No nodule forms at the point of reinoculation, but during the following day or two a small area of skin becomes necrotic and sloughs, leaving superficial ulceration which heals quickly and completely. While foci already existing within the animal may be activated, there is no fresh spread of infection from the point of inoculation. This observation, now abundantly confirmed, has explained much that is otherwise difficult regarding events in the life-history of the tuberculous patient. When once tuberculized, the affected individual seems to be protected from a fresh entry of bacilli into his system. To that extent the initial infection exerts a defensive influence. The effect of subsequent absorption of bacilli following repeated re-exposure to infection is not to start a fresh chain similar to that following the first infection, but rather to activate existing foci and thereby lead to an aggravation of symptoms either by extension of a localized lesion or by the carriage of bacilli from a localized lesion to other parts.

It was observations along these and cognate lines which led Koch to the elaboration of tuberculin. Regarding the significance of tuberculin in different fields I shall have more to say. In the meantime it is important to note that effects similar to those just described as following reinoculation with living bacilli followed also when, in place of living organisms, bacilli sterilized by boiling or by chemical agents were introduced. This led to the view that within the body of the bacillus there exist elements related to the life-history of the bacillus which have active properties capable of affecting the animal which harbours the bacilli. These elements were separable from the bodies of the bacilli and from the culture medium in which the bacilli were growing. Koch's original tuberculin—and tuberculin in its various forms—consists of an extract obtained from the bodies of the bacilli or from the culture medium, or from both. Tuberculin, therefore, has specific relationships with the tubercle bacillus and, when brought into the presence of the tubercle bacillus in animal or man, reveals this relationship by certain recognized reactions. These reactions led naturally to the application of tuberculin in diagnosis and treatment.

PRACTICAL APPLICATIONS OF HIS WORK

While the science of bacteriology was thus advanced by the investigations associated with the discovery of the bacillus, Koch's vision reached still further. With superlative finesse he lifts the curtain and reveals the far-stretching vista and the fresh orientation which the dis-

covery gave to preventive medicine and to the practice of medicine and of surgery:

"Wenn sich die Überzeugung, dass die Tuberkulose eine exquisite Infektionskrankheit ist, unter den Ärzten Bahn gebrochen haben wird, dann werden die Fragen nach der zweckmässigsten Bekämpfung der Tuberkulose gewiss einer Diskussion unterzogen werden und sich von selbst entwickeln."

The infectivity of tuberculosis having been established beyond dispute, it became evident that the problem of its prevention and treatment in the individual, and throughout the population, must be handled on the broad principles which were applicable to other infections. It was equally clear that the matter presented difficulties inherent to the disease itself.

The course of tuberculosis differs widely from that of other infections. Tuberculosis is peculiar in respect of the extent and mode of its dissemination from man to man and from animal to man, and peculiar by reason of its prolonged course and the conditions of environment on which its dissemination and its varying manifestations depend. It was obvious that methods to combat tuberculosis could not be modelled entirely on those which had been found serviceable for other infections. Every move centred round the recognition of the bacillus as *causa peccans*. The detection of the bacillus by one or other means afforded for the first time infallible evidence as to the presence of tuberculosis. The physician and the surgeon had no longer to grope in the dark. A definite purpose was given to measures for prevention and treatment. Time-honoured beliefs were subjected to revision. The doctrine of the heredity of tuberculosis—deeply ingrained in the popular imagination, and little less in that of the doctor—was exploded.

With a still wider sweep, the discovery inaugurated the scientific study of the natural history of tuberculous infection. Facts became available both from the experimental animal and from the human subject. Those afforded by the former served as key to the interpretation of the latter. The complex human problem was clarified by the facts of experimental pathology. The guinea-pig, rabbit, calf, and monkey have been good friends to the student of tuberculosis.

The widespread distribution of tuberculosis throughout the community, its appalling mortality, its apparent emergence at all ages, the protean character of its manifestations, and the interrelationship of human and bovine infection, called for thoughtful study. Of hardly less importance was the economic stress and hardship produced by the long continuance of ill-health and the crippling effect on remunerative labour.

DISPENSARY AND SANATORIUM

It became speedily evident that there was an urgent need for the collection of facts concerning the ubiquitous disease. The recognition of this led to the establishment of the first Tuberculosis Dispensary in 1887. These intelligence centres are now distributed throughout the world. It is to the properly organized dispensary that we should look for further contributions to our knowledge regarding the natural history of tuberculosis. It is difficult to overestimate the value of *continuity of observation and record regarding tuberculosis throughout the life-time of the individual*, and it is to be regretted that the conduct of these intelligence centres is often relegated to inexperienced officers. Dispensary staffs should not limit their energy to the care of individual patients who present themselves for examination, but should be a mobile force, ready to hunt down the enemy in a systematic search for *all* cases in their area, and qualified to interpret the associated circumstances. The significance of such observations hastened the introduction of compulsory notification. Another primary need for dealing

with the disease was the establishment of residential institutions for the segregation of the more infective cases. In illustration of the need, records of the Victoria Tuberculosis Dispensary from 1887 to 1907 showed (International Congress, Washington, 1908) that in 61.4 per cent. of cases under observation there had existed in the home surroundings all the possibilities of infection—that is, the patient had been for a long period in the closest proximity to at least one case of advanced tuberculosis, while in another 11.7 per cent. direct infection was probable. Furthermore, in 65.9 per cent. the tuberculous patient occupied the same bed with one or several persons, and in 11 per cent. more, he or she occupied the same room.

Such facts impressed Koch with the urgent necessity for the segregation of the more infective cases in a special hospital, and for the careful control of the domiciliary conditions—especially the sleeping arrangements—of the large number of patients, who for one reason or another could not be placed in hospital. In one of his latest papers ("Epidemiologie der Tuberkulose," vortrag gehalten in der Akademie der Wissenschaften zu Berlin am 7 April, 1910) Koch expressed himself as follows:

"Diese Betrachtungen zeigen, dass die Abnahme der Schwindsucht in neuerer Zeit durch verschiedene Faktoren bedingt wird, von denen die beiden wichtigsten die Krankenfürsorge mit Isolierung der Phthisiker in Krankenanstalten und die Verbesserung der Wohnungsverhältnisse, insbesondere des Schlafraumes sind.

Es geht daraus hervor, welche ungeheuren Hindernisse noch überwunden werden müssen, ehe es gelingen wird, die Schwindsuchtsmortalität immer weiter herabzusetzen."

With regard to the sanatorium for the curative treatment of tuberculosis, Koch's attitude was that of scientific reserve. Having regard to the wide distribution of the infection, he realized that the effective part played by the sanatorium was limited. The value of the sanatorium was inevitably dependent on the care with which really curable cases were selected, and on a sufficiency of time being allowed for completion of the cure. Those essential conditions were—as in many cases they still are—notoriously neglected. On the other hand, Koch was fully appreciative of the significance of the physiological principles underlying sanatorium methods and their universal applicability in the treatment and prevention of tuberculosis.

He recognized further that, if it was the part of medical science to point the way, success in the campaign against tuberculosis would in the long run depend on the diffusion of knowledge throughout the people. They must be armed for self-defence. How thoroughly Koch envisaged the effect of enlisting public opinion in support of the campaign is evident from the following quotation:

"Dazu rechne ich in erster Linie alle die Bestrebungen, welche darauf gerichtet sind, durch populäre Schriften, Vorträge, Ausstellungen und sonstige derartige Mittel Belehrung über die Tuberkulosegefahr in das Volk zu tragen und das Interesse der breiten Volksschichten für die Tuberkulosebekämpfung wach zu halten." (Nobel-Vorlesung, 12 Dezember, 1905.)

TUBERCULIN AND ITS USES

This brief tribute to the memory of the master must not close without further reference to the wide sweep of his untiring researches which culminated in the elaboration of tuberculin. If the discovery of the tubercle bacillus afforded the central illumination point, the subsequent production of tuberculin has likewise thrown a flood of light on the entire field of tuberculosis. Its application in widely varied fashion has opened fresh paths of knowledge regarding the extent and significance of tuberculous infection. Epidemiological investigations rendered possible by means of tuberculin have disclosed a wide vista, and gradually clarified one issue after another of a very complex problem.

In the practical sphere, the evidence afforded by tuberculin in relation to diagnosis in man and cattle—in the absence of direct proof of the presence of the bacillus—has been of priceless value. Thus, in the bovine sphere, it has made possible the establishment of tubercle-free herds and the production of tubercle-free milk. It would be difficult to overestimate the help afforded by its regular use in the service of the Tuberculosis Dispensary. It is my firm conviction, having regard to the frequency of tuberculous infection in childhood, and the possible consequences of such infection, that the use of tuberculin as a diagnostic agent should become routine practice from early infancy onwards. The fact of infection, and the date of its first detection, are of first-class importance in the life-history of the child. So long as reaction to the test continues negative, there is no need for further action. If, following positive determination, the health of the child remains good, we know that the child's resistance is equal to the occasion. There is no need for special care. The occurrence of the positive reaction, however, may prove the key to the interpretation of numerous doubtful events in the life-history of the child—for example, obscure feverish attacks, unexplained malnutrition, ill-defined lack of energy, disturbed action of the heart, which may interfere with the normal course of development and education.

"Such determination is the first essential step towards effective detubercularization of the individual and, ultimately, of the community. The procedure is harmless and costs little. Yet its general adoption would result in the anticipation and limitation of countless consequences in the shape of invalidism and crippling. It is the lack of such scientific anticipation which has created, and meantime maintains, the need for sanatoriums and hospitals all over the country. As I put it in 1912: It is to the nursery and schoolroom that observation and effort should be directed if measures for the eradication of tuberculosis are to be fundamentally sound and practically effective." (*British Medical Journal*, January 10th, 1934.)

Turning to the therapeutic side my words will be few. The terms used by Koch in his communication regarding tuberculin as a remedial agent (*Deut. med. Woch.*, December, 1890) were simple, clear, and temperate. He was not responsible for the excited enthusiasm, medical and lay, which knew no bounds, nor for the mad rush of sick and dying to Berlin: nor for the inevitable disastrous reaction which, like the initial excitement, was exaggerated and bore little relation to the facts. I can never forget Koch's personal kindness in the midst of the turmoil. When I visited Germany in December, 1890, Berlin presented its coldest wintry aspect; but Koch's reception was most friendly when, armed with an introduction from the revered Rudolf Virchow (who was already definitely critical), I obtained from him a small flask of the brown-coloured fluid. Accepting his personal testimony and the evidence submitted by reliable colleagues, I commenced observations immediately on my own account. That was over forty years ago.

Results from the first led me to take a favourable view of its possibilities. With accumulating satisfactory experience tuberculin has been used by me in one or other form, and according to one or other procedure, without interruption up to the present time. Its continued employment has steadily confirmed my judgement in favour of its claim to be a specific remedy of much value—subject always to the proviso that, as with other potent remedies, its successful administration implies skill and experience in the selection of the suitable case and in the regulation of dosage. Distrust in its value I have found commonly expressed in loudest terms by those whose acquaintance with tuberculosis is limited and whose knowledge of the actual treatment is fragmentary or second-hand. Koch must not be held accountable for

the intemperate statements either of supporters or of critics. Nor be it thought that in the sphere of treatment Koch's outlook was limited to tuberculin and its applications. He approached the consideration of treatment from many angles. His incessant labours pointed the way to most subsequent developments in the direction of active and passive immunization, and no less to the ever-recurring search for chemotherapeutic agents. The investigators in tuberculosis are few who have not sometimes been surprised by evidence—in whatever corner of the field their research—that Koch had paced the ground before them.

I think it may surely be said without fear of dissent that in few, if in any, departments of medicine has there occurred during fifty years so complete an upturn of thought and practice as in that of tuberculosis. The credit for this is primarily due to Koch. To him we owe it that knowledge has replaced ignorance, that doubt and helplessness have largely disappeared, that preventive measures and therapeutic procedure are now inspired and controlled by ascertained fact, that the morbidity of tuberculosis has lessened, and that in all progressive countries the mortality from tuberculosis is tumbling rapidly. Robert Koch laid the solid foundations on which the rest has been built, and to him be the glory.

A British Medical Association Lecture

ON

NASAL SINUS INFECTION*

BY

WALTER HOWARTH, M.A., M.B., F.R.C.S.

SURGEON TO THE EAR, NOSE, AND THROAT DEPARTMENT, ST. THOMAS'S HOSPITAL; PRESIDENT OF THE LARYNGOLOGICAL SECTION, ROYAL SOCIETY OF MEDICINE

The nasal accessory sinuses are lined, like the nasal cavity itself, by a ciliated mucous membrane which, however, is not so rich in mucus-secreting glands. The action of the cilia, which work upwards towards the ostia, normally keeps the sinus free from secretion.

The reactions of the mucous membrane to infections have recently been the subject of research, and it is perhaps legitimate to conclude that retention of mucus or of pus in a sinus is an indication that the cilia have failed in their attempt to remove this, owing to damage to, or destruction of, the ciliary mechanism. The aim of surgery in treating sinusitis is to remove the discharges from the mucous membrane in order that it may be rested, and may utilize such power of spontaneous recovery of function as it possesses. What, then, are the infections that attack the nose, and why should such infections involve the accessory sinuses? It is being more and more clearly recognized that mucous-lined cavities are subject to catarrhal and infective inflammation, somewhat in proportion to the degree of obstruction to their drainage and ventilation. Thus it is in nasal cavities that show some deviation from the normal that nasal sinus infection is more likely to occur. It is certainly unusual for these complications to occur in a perfectly healthy nose unless the original infection is a very virulent one or the resistance of the individual is for some reason considerably lowered. The predisposition of individuals to upper respiratory tract infections has been shown to be increased when vitamin A is deficient in the diet, whilst a lack of endocrine balance, and occasionally some form of allergy, are other factors that lay the mucous membrane open to infection.

There seems to be no doubt that influenza is the most potent factor in the causation of sinus affections, though any organism that can cause an acute coryza (and I include here those organisms associated with the specific fevers) may, if conditions are favourable, produce sinus complications.

ABNORMALITIES PREDISPOSING TO SINUSITIS

It may be well, for a moment, to turn our attention to a consideration of the nasal passages and some of the common abnormalities that are met with there. There is no need to remind you that the outer wall of the nose is its most important part, because it is under the middle turbinate that the anterior group of sinuses have their openings. The frontal sinus lies most anteriorly, then come the anterior ethmoidal cells, the maxillary antrum further back, whilst above the middle turbinate the posterior ethmoidal cells and the sphenoidal sinus open into the spheno-ethmoidal recess. Consequently all forms of nasal obstruction, either by actual pressure or by inducing congestion, may interfere with the drainage from these sinuses or affect their aeration, and so render them more sensitive to the spread of infection from the nasal passages.

A deviation of the septum, whether traumatic or otherwise, naturally plays a large part in causing obstruction in the middle turbinate region. This is the most serious form of obstruction, as it causes more severe inflammatory disease of the accessory sinuses than does obstruction elsewhere, for such a deformity may interfere not only with the drainage and ventilation of the anterior group of sinuses, but also, by blocking the olfactory fissure, may impair that of the posterior ethmoidal cells and sphenoidal sinuses as well. Besides high deviations of the septum there are other conditions which may cause obstruction in the middle turbinate region.

We have hypertrophic conditions of the middle turbinate itself and extra air cells in the middle turbinate, which is merely a folded-over portion of the ethmoidal labyrinth. These may close the olfactory fissure, or press unduly on the diastemum semilunaris. Then again, an enlarged bulla ethmoidalis may obstruct the hiatus semilunaris and disturb its contour, thus interfering with the ventilation and drainage of the anterior group of sinuses. Finally, the infundibulum itself is often surrounded by ethmoidal cells, and an extra large one in the region of the uncinat process may block the infundibulum and so cause a predisposition to infection and inflammation.

The conditions mentioned are by no means unusual, and when combined with the appropriate pathogenic micro-organisms and a lowered resistance of the individual, it is scarcely to be wondered at that nasal sinus infection is so commonly met with.

EXAMINATION OF A TYPICAL CASE

It will now be well to consider an acute infection of nasal origin and its mode of spread to the sinuses.

When infection occurs I think it is true to say that the maxillary antrum is always involved in the process. Though the antral condition may often subside and leave some other sinus more prominently involved, in the initial stages it seldom, if ever, escapes. When, during a common cold, the symptoms such as headache, pain, tenderness, unilateral nasal discharge, redness or swelling of the face lead one to suspect a sinus infection, a careful nasal examination must at once be undertaken. The mucous membrane will be found to be intensely engorged. Introduction of a pledget of cotton-wool wrung out of 20 per cent. cocaine will not only mop up any secretion, but will also cause the inflamed mucosa to shrink, and make

* Read before the Chesterfield Branch on March 11th.