EARLY IMMUNIZATION, THE ESSENTIAL FUNCTION OF THE TONSIL.*

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One of the greatest problems under consideration at the present time, by workers along the lines of scientific physiology, pathology and therapeutics, is that of immunity, and I purpose in this paper to show the part the tonsil takes in establishing this condition.

As late as 1907, one of the leading men in the profession, George Bacon Wood, states that "the real reason for the existence of the tonsil has not yet been explained."

The tonsil is so located that it is exposed to bacteria coming to it by way of the nose, mouth, lungs and stomach. Every mouthful of food loaded with micro-organisms is crushed by the tonsil in the act of swallowing. The secretions from the nose are carried toward the tonsillar crypts by the cilia, as demonstrated by Jonathan Wright. The secretions from the lungs are coughed or carried by the cilia directly toward the tonsils. So in the act of vomiting, which is frequent in infants, the contents of the stomach are brought directly in contact with the tonsils.

From these facts one is led to believe that the tonsil must have an important function or else it would not be placed where it is exposed to infection.

The tonsil in the embryo does not develop until the fourth or fifth month, so that we may conclude, first, that whatever be the function of the tonsil it has not functionated prior to this period; and, second, that it cannot have a vital embryonal function or else it would develop earlier in foetal life. At birth the tonsil is fully developed, having matured histological structures, and therefore is able to perform its function.

That the tonsil functionates early in life is suggested, first, by the fact that when tonsils are enucleated after about three years of age, the system knows no loss. Second, the tonsil like adenoids, in healthy children, who have had no attacks of tonsillitis, has a tendency to atrophy or decrease in size from the third or fourth year up to puberty.

Many theoretical functions have been ascribed to the tonsil. Spicer thought it eliminated certain elements from the system,

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which, however, is proved to be false by chemical analysis of the contents of the crypt. Massini advanced the theory that the tonsil furnished an internal secretion like that of the ductless glands. None of the histological tissues in the tonsil could produce secretions like those found in the ductless glands. Fox considered the tonsil as having the property of absorbing salivary digestion. Gulland gave the tonsil a bactericidal function, namely, that of destroying bacteria which enter the alimentary tract by way of the mouth. The only material in the crypts having this power is the salivary corpuscle, and we know that the great number of bacteria entering the system by way of the mouth are many times more than could possibly be destroyed by the salivary corpuscles. Furthermore, nearly all bacteria when entering the stomach lose their pathogenic potency.

George Bacon Wood has very elaborate drawings with which he attempts to show that the stratified epithelial cells at the bottom of the crypts are transformed into leucocytes, and considers the tonsil the primogenial source of leucocytes. This would overthrow all of our views that the leucocytes have their origin from the original mesoblastic elements.

Notwithstanding the hopeless foundation for the above-mentioned theories, there are some facts which have been demonstrated, that serve as a basis for logical conclusions. For example, Goodale noted, first, that salivary corpuscles possessed phagocytic properties; second, that the lymph currents promoted by the ciliated epithelium of the oronasal cavities converge towards the region of the tonsil; third, that this lymph passes into the cervical lymphatics through the tonsils.

Wright noted that foreign particles, such as carmine granules, oil globules, etc., pass with the lymph current through the cryptal epithelium into the tonsil and that living bacteria remain in the crypts.

With these established facts in mind we are in a position to understand clearly the function of immunity performed by the tonsil.

Immunity may be defined as that which prevents the gaining of a foothold by disease germs into the body, or that which neutralizes their harmful products or destroys the organisms.

However, immunity is only relative, and whether an individual suffers from the disease after the germs have been introduced into its system, depends on two factors: the pathogenic potency of the germs, and the vital resistance of the individual. For example, a fowl under ordinary or normal conditions is immune to inocula-

tions with the germs of tetanus, yet if the chicken be compelled to remain in a refrigerator and stand in a piece of ice for a time, it becomes susceptible to the inoculations of tetanus and dies.

An organism may possess an *inherent immunity,* as in the case of the fowl to tetanus, or man to certain diseases affecting animals. This form of immunity is theoretically interesting but practically valueless.

It is the acquired immunities which are of interest to us in the functions of the tonsils. There are two forms, natural acquired immunity and artificially acquired immunity. *Natural acquired immunity* is immunity established by the natural forces of the tissues of the body, when disease organisms exist for a time within the individual, giving their products to its system. This is exemplified in such diseases as tonsillitis, diphtheria, measles, etc.

Artificially acquired immunity, or artificial immunity, is induced by the inoculation with live germs causing the disease, or by the injection of the products of the organism. This product may be found in fluid media after extraction from the bacterial body, or it may be inherent to the bacterial body, in which case the organisms are thoroughly sterilized before injection.

Any material used to induce this immunity by inoculation or injection may be known as vaccine.

A vaccine may be defined as any substance of bacterial origin which, when taken into the body fluids, is capable of inciting an elaboration of protective substances.

Protective substances or antibodies are certain specific substances with antagonistic properties, in the body fluids, which aid the bodily resistance by one of two forces or both,—mechanical, as phagocytosis and opsonic power, and chemico-physiological, as agglutination and bacteriolysis.

All these powers may be present in the resistive manifestations in equal or varying degrees, or one or more may be totally absent.

Agglutination is the process brought about by the union of the bacterial product known as agglutinogen with the substance normally present in the body known as agglutinin, and is manifested by the power of causing evenly distributed bacteria to clump together; in other words, become paralyzed, as is the case in typhoid fever.

Bacteriolysis is the process by which the resistive elements of the tissue bring about a disintegration or lysis of the bacteria.

Opsonic power is the ability the fluids of the body possess in preparing pyogenic bacteria for the process of phagocytosis.

Phagocytosis consists of the destruction of bacteria by a phagocyte, subsequent to preparation of the bacteria by the opsonins.

A phagocyte is any cell which has the power to take within itself a foreign substance and destroy it. It may destroy the substance (bacteria) by a sort of digestive process, or it may, after taking within itself a large amount of foreign material, give itself to the excretory tracts, and thus destroy the substance and itself.

Opsonins are substances distributed throughout the body fluids and are produced as a result of a reaction on the part of the fixed tissue cells to irritation from bacterial substances. They alter the resistance of, or prepare the bacteria so that the phagocytes have the power to ingest them.

Artificially acquired immunity may be established in two ways:

1. By injecting bacteria or their products into an individual whose fixed tissue cells will respond with the formation of protective substances or antibodies. These protective substances aid the bodily resistance by neutralizing the bacterial products or by destroying the bacteria themselves. These protective substances may remain potential for months or years, thus rendering a temporary if not permanent immunity. When immunity is secured in this manner by the sole activity of the cells of the individual affected, it is termed *active immunity.*

2. If the serum of an actively immunized animal be obtained and injected with its protective substances into a second animal, an immunity is established without the cellular activity necessary in active immunization. This process is termed *passive immunity.*

If the serum used in the production of passive immunity contains only the property of neutralizing the toxic products of the infecting bacteria, it is known as *antitoxic passive immunity.* It will be observed that the bacteria against which an antitoxic immunity may be established give off their poisonous substances while alive. The immune serum so produced is known as *antitoxic serum,* and is represented by such serums as antidiphtheritic, tetanic, and the antitoxic serum of botulism.

It is also observed that some bacteria give off a toxin after they are killed and are undergoing disintegration. A serum introduced in passive immunity which destroys the organisms is known as an *antimicrobic serum.* This explains the toxemia following the introduction of antimicrobic serums. Almost all serums on the market are antimicrobic, except those mentioned above. All immunities, except inherent immunity, may be produced through the tonsil, by

any of the processes above described. Natural acquired immunity is brought about by acute inflammatory processes in the tonsil. Artificially acquired immunity is produced by the processes of bacteriolysis, agglutination or opsonic power in the crypts of the tonsil.

The location of the tonsil is such that the bacteria entering the oronasal cavity, from the day of birth, are directed towards the tonsillar crypts. The crypts are lined with stratified epithelium (not columnar), so that they are simply receptacles or culture tubes in which bacteria of every variety, entering the fauces, may be cultivated. The mucus in the crypts serves as the culture medium. The bacteria remain in the crypts, not because the cryptic epithelium has a special selective power, as claimed by Wright, but because, being living organisms, they select the mucus in the crypts in preference to going along with the lymph current underneath the epithelium as is the case with dust particles.

The glands which furnish this culture mucus in the crypts are located just outside the tonsillar structure. (Fig. I.)

Dr. Orndoff has named these glands peritonsillar mucous glands. The glands are compound racemose mucous glands situated around the tonsil in the region of the capsule and its trabeculae. They are found in all tonsils properly enucleated, and they are most numerous at the base of the tonsil near the bottom of the crypts. These glands have ducts which empty into the crypts. This explains how peritonsillar abscesses at times follow follicular tonsillitis.

The bacteria multiplying in the crypts give off products called vaccines, which are taken into the tonsil by the lymph current and thence into the entire system, where they come in contact with the fixed tissue cells, which in turn have the power of producing antibodies, such as opsonins, agglutinins, etc., which, as described above, produce immunity.

We must now describe how the bacteria are removed from the crypts after they have fulfilled their part of immunization. There is neither fight nor affinity between the salivary corpuscle and any particular bacteria so long as the body is not immunized against these bacteria.

To illustrate, pyogenic bacteria entering a crypt of an infant just born will thrive there unmolested by leucocytes until its vaccines absorbed into the system cause the tissue cells to produce opsonins, which come into the crypts with the lymph and prepare the pyogenic bacteria for phagocytosis. The salivary corpuscles now seize

the bacteria and together they are forced out into the oral cavity in the act of swallowing. This process of leaving bacteria in the crypts just long enough to establish immunity and then be carried out by phagocytes produces what has been termed by Dr. Orndoff "tonsillar equilibrium." In the act of deglutition the superior constrictor muscles compress the peritonsillar glands and force the mucus into the crypts, and this same force or pressure forces the contents of the crypts into the oral cavity. The tonsil with its

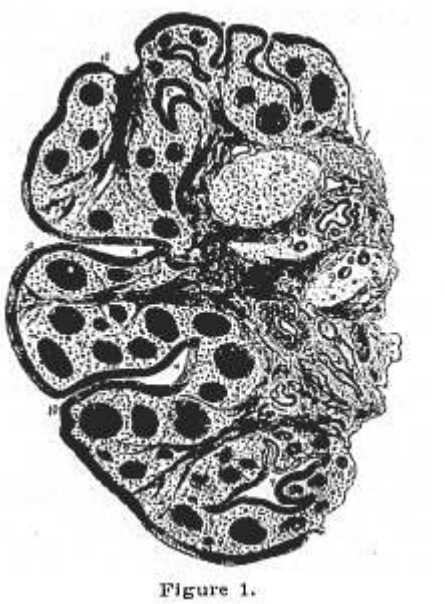

Figure 1.

1. Peritonsillar mucous glands.
2. Ducts of mucous glands opening into crypts through
3. Stomata.
4. Crypts.
5. Lymph follicles.
6. Interfollicular tissue containing lymphocytes and polymorphear leucocytes.
7. Connective tissue.
8. Diseased lymph follicle.
9. Diseased peritonsillar mucous gland.
10. Epithelium.
11. Diseased epithelium.

crypts makes it possible for the system to gradually absorb the vaccines from the crypts and thus produce immunity without systemic toxemia such as we have with acute infections. Agglutination and bacteriolysis can likewise take place in the crypts; the former, coagulating or clumping together the bacteria, the latter, destroying and absorbing them.

The interfollicular tissue is composed of interlacing stellate connective tissue cells whose spaces are filled with lymphocytes and polynuclear leucocytes; thus a tissue is arranged which offers every protection to the general lymphatic system from the insoluble particles (foreign bodies) which pass through the cryptal epithelium.

We shall thus see that the real physiological phenomena found by Goodale, Wood, Wright and others are all required in the process of immunization as brought about through the tonsil.

If the body needs to be immunized to ward off or prevent the invasion of bacteria, it stands to reason that the time when this function is mostly needed is when the infant is first exposed to these bacteria. That the child of one year of age is not thoroughly immunized as yet, is indicated by the fact that the fatality of infants attacked with pneumonia, diphtheria, scarlet fever, etc., is much higher than later in life.

Though the normal tonsil probably functionates until puberty or later, we are nevertheless forced to believe that the time when it is mostly needed is immediately after birth, up to the third or fourth year. That the tonsils are not absolutely needed after this period is shown by the fact that when they are enucleated the system knows no appreciable loss. That the remainder of Waldyer's lymphatic ring may take up this function of the tonsil is quite probable; in other words, the function of Waldyer's lymphatic ring is probably that of early immunization.

The practical conclusions are: first, that in children under two or three years of age, the tonsil when removed should not be completely taken out; second, that only diseased tonsils should be enucleated; and third, when a tonsil has become pathological its function is altered so as to make it possible to become a portal for systemic infection.

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