ANATOMY AND PHYSIOLOGY OF THE
TONSIL*

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The tonsils are two masses of lymphoid tissue placed one in each tonsillar fossa and projecting into the oropharynx. They are oblong in shape with the long axis vertical. They are from 1.75 to 2.5 cm. in length and from 1.5 to 2 cm. in transverse diameter. In children under the age of eight they are usually larger, from 2.5 to 3 cm. in long axis by 1.5 to 2.5 in transverse diameter. They are covered by stratified epithelium of

Fig. 1.—Showing anterior pillar (after Toldt): M. L. V. P., M. levator veli palatini; M. S., M. styloglossus; M. P.-P., M. pharyngopalatinus; M. G.-P., M. glossopalatinus; T. P., tonsilla palatina; M. T. V. P., M. tensor veli palatini; A. P.-P., arcus pharyngo-palatinus; A. G.-P., arcus glossopalatinus; D. P., dorsum linguae.

the mucous membrane and their pharyngeal surface is marked by small apertures which indicate the openings of the crypts. The epithelial lining of the crypts is reflected from the surface covering.

The tonsils are composed almost entirely of lymphoid tissue which at intervals is aggregated into lymph nodes in which the lymph cells are more intimately arranged than elsewhere. The lymphoid tissue is surrounded by a dense capsule of connective tissue and the gland is divided into pockets by the trabeculae, which are composed of connective tissue. The tonsil is part of the lymphatic circle which surrounds the oropharynx, called Waldeyer's ring.

In the neighboring part of the pharynx near the Eustachian tube, the upper part of the pharynx and the base of the tongue, there are masses of lymphoid tissue similar in structure to that of the tonsil, which also contain crypts.

FORMATION OF THE TONSIL

The tonsil makes its appearance about the fourth or fifth month of gestation. At birth it is a gland from 0.5 to 1 cm. in its long axis and from 0.25 to 0.5 cm. in lateral dimension. It develops as the child grows, reaching its full size between the sixth and eighth year of life. After this period it begins to atrophy and has disappeared by the twelfth year. At birth it is enclosed in the tonsillar fossa, being completely covered by the plica tonsillaris. Shortly after birth this membrane disappears, leaving the inner surface of the gland exposed to the oropharynx.

It is small at birth as compared with the thymus or thyroid gland. It is formed in the fetus by an invagination of the hypoblast which forms the capsule and the trabecular pouches or areas. The epiblast extends down into these trabecular areas and forms the crypts around which lymphatic tissue develops.

Fig. 2.—Showing posterior pillars (after Toldt): C. T., cartilago tubae; M. L. V. P., M. levator veli palatini; M. S.-P., M. salpingopharyngeus; M. C. P. S., M. constrictor pharyngis superior; M. U., M. uvulae; M. P.-P., M. pharyngopalatinus; R. L., radix linguae; M. T. V. P., M. tensor veli palatina; M. D., M. digastricus; M. S.-P., M. stylopharyngeus; M. S.-H., M. stylohyoideus; U. P., uvula palatina; T. P., tonsilla palatina; M. P.-P., M. pharyngopalatinus.

ANATOMIC DESCRIPTION

The tonsil is situated between the anterior or glosso-palatine fold and the posterior or palatopharyngeal fold. It is covered externally by the superior constrictor muscle. It does not completely fill the tonsillar fossa, there being a space above which is known as the supra-tonsillar space, or fossa, and it is sometimes found in unusual positions.

One case is reported in which the gland occupied a position on the posterior pillar just under the Eustachian tube. In two other cases the tonsil was attached to the posterior pharyngeal wall behind the uvula. In these cases the gland was pedunculated but contained well-defined crypts.

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Palatal Pillars.—The anterior pillar is formed by the palatoglossus muscle, which is attached above to the aponeurosis of the velum and has its insertion in the tongue. Its action is to constrict the isthmus of the fauces and holds the tonsil back in place. The free edge is often attached to the tonsil by inflammatory adhesions from repeated attacks of tonsillitis. It may vary considerably in thickness and appear as a rough red membrane, with the outline indistinct or irregular. In other types it may appear so thin as to be almost transparent. At times the anterior pillar is found attached to the posterior pillar by a thin membrane which may be complete or partial, which is the remains of the plica tonsillaris (Fig. 1).

The Posterior Pillar.—This tissue is formed by the mucous membrane fold in which is contained the palatopharyngeus muscle. This muscle arises in the soft palate with fibers from its fellow of the opposite side. It passes partly above and partly below the levator palati and azygos uvulae muscles. After forming the posterior pillar of the fauces the internal fibers are inserted into the pharyngeal aponeurosis and the external fibers pass forward to be inserted into the posterior border of the thyroid cartilage. The action of this muscle is to contract the isthmus of the fauces and to lift the soft palate. During inspiration the two pillars meet or nearly meet in the median line, thus shutting off the oral cavity from the respiratory tract (Fig. 2).

Plica Tonsillaris.—Some authors divide this membrane into two parts, the plica supratonsillaris and the plica triangularis. In truth the plica supratonsillaris is only a remaining part of the plica tonsillaris. The term plica triangularis should be discontinued because

does persist it is a continuation of the edge of the anterior pillar and may join the two pillars above, forming a band or fold over the upper part of the tonsil. The most common manifestations, however, are those tonsils which have the anterior edge covered by this membrane to a greater or less extent. It is impossible in many cases to define the edge of the anterior pillar.

Fig. 4.—Schematic circulation circle of tonsil: A. P. D., A. palatina descendens; A. Ph. A., A. pharyngea ascendens; A. R. T., A. ramus tonsillaris; A. T., A. tonsillaris; A. C. E., A. carotis externa; A. M. E., A. maxillaris externa; A. L., A. lingualis; A. D. L., A. dorsalis linguae; A. P. A., A. palatina ascendens.

In 1906 I read before this Section a paper describing the common types of this membrane, mentioning, among others, a case in which the membrane completely covered the tonsil in an adult.¹

Supratonsillar Fossa or Recessus Palatinus.—The supratonsillar fossa is a triangular, conical space with the apex outward, and when normal represents a considerable cavity above the tonsil. Its walls are formed by the anterior and posterior pillars, while the floor is formed by the superior surface of the faucial tonsil. It varies in size in different individuals and may differ from the fossa of the opposite side. It may extend downward and outward, external to the tonsil, or up and outward into the soft palate. There may be sinuses extending off from this space in one or more directions. This fossa is of importance from the fact that there are crypts emptying into this space and when the communication with the pharynx is imperfect or absent a collection of caseous material may be extruded from the tonsil, held in this space. This condition is the great cause of the infections which pass through the gland into the cervical lymphatics, and also the cause of the different types of quinsy from decomposition of this extruded material held in the supratonsillar space.

CAPSULE OF THE TONSIL

The tonsil has a capsule extending from the free edge of the pillars covering the external surface of the gland which furnishes support as well as an investing covering. This capsule is composed of connective tissue about 1 mm. in thickness and is smooth on the external surface. From this capsule bands of connective tissue called the trabeculae are given off, which extend to the inner surface of the gland dividing it into spaces

Fig. 3.—A. P. D., A. palatina descendens; A. T., A. tonsillaris; A. M. E., A. maxillaris externa; A. L., A. lingualis; A. P. A., A. palatina ascendens. (Modified after Toldt.)

this membrane is not triangular in shape. Plica tonsillaris gives a better understanding of the correct significance of the membrane, which at birth is a normal embryonic tissue but which should completely disappear before the second year. If present after this age it is an abnormal remnant. When the plica tonsillaris

1. Faucial Tonsils, THE JOURNAL A. M. A., 1906, xlvii, 1725.

called the trabecular areas. In these trabecular bands lie the vessels, nerves, mucous ducts and lymph channels.

In some of the lower animals we find muscular tissue in these bands, but not in human beings.

Trabecular areas are supposed to be separate and distinct spaces, although Beck has injected bismuth paste into one crypt and has seen it communicate with four or five other trabecular spaces.

The youngest patient was eight years of age, while all the others were adults. This communication be-

Fig. 5.—A. P. D., A. palatina descendens; M. C. S., M. constrictor superior; A. P. A., A. palatina ascendens; M. S. G., M. styloglossus; A. M. E., A. maxillaris externa; A. C. E., A. carotis externa; A. C. I., A. carotis interna; A. R. T., A. ramus tonsillaris; A. D. L., A. dorsalis linguae; A. L., A. lingualis. (After Toldt.)

tween crypts is at variance with my experience and I am inclined to the belief that the phenomenon observed by Beck is pathologic.

CRYPTS

The crypts vary in number and length. Some authors place the number at from fifteen to eighteen. I have seen many tonsils which had as few as four or eight. The number depends upon the size and condition of the tonsil examined. In the upper half of the tonsil the crypts are longer, usually extending downward and outward to the capsule on the external surface of the gland. Those opening below the middle of the gland extend outward or outward and upward. They are much shorter than the upper crypts. The upper crypts, especially those which empty into the supratonsillar fossa, are usually filled or partially filled with caseous material, while those emptying directly into the pharynx are seldom found with material in the crypt. This fact is easily explained by remembering that when swallowing the tonsils are squeezed by the palatal and superior constrictor muscles. This empties the crypt of material if there be no obstruction at its mouth, in which case the material cannot escape from the pressure of the obstruction.

If there be a tonsil which fills the supratonsillar fossa or a plica tonsillaris covering over the crypt walling the supratonsillar fossa off from the pharynx the material in the crypt can not be expelled, or if expelled is held in the supratonsillar fossa, and in this case it follows the line of least resistance, which usually is deeper

into the crypt. Thus there may be a crypt, or number of crypts, enlarged at the distal end, or branching sinuses may be produced. This would perhaps account for the bismuth paste finding its way into three or four different crypts, as seen by Beck.

The crypt is lined by stratified epithelium. This membrane is much thinner than the surface membrane, and some observers assert that it disappears in the extreme depth of the crypt. At places in pathologic glands this crypt lining is very thin, from the presence of great numbers of lymphocytes, which seem to separate the lining membrane cells. The subepithelial tissue is also lost in the crypt, the lymphoid cells coming in direct contact to the crypt wall.

BLOOD VESSELS OF THE TONSILS

The blood supply of the tonsil is derived from (a) the tonsillar artery, which is a branch of the external maxillary near its origin from the external carotid; (b) from the ascending pharyngeal, which is given off from the external carotid just above the bifurcation of the common carotid; (c) from the ascending palatine, a branch of the external maxillary; (d) from the dorsalis linguae by one or two branches from the lingual.

These arteries supply the tonsil and tonsillar space as follows:

(a). The tonsillar artery is given off from the external maxillary, a branch of the external carotid (Figs. 3 and 4). It passes upward and forward under the jaw and the internal pterygoid muscle and under the styloglossus into the loose fatty tissue of the pharyngomaxillary space. At or below the middle of the tonsil the artery gives off a branch which passes to the buccopharyngeal fascia which covers the superior constrictor muscle externally. Here the artery divides into a superior and an inferior branch. These two branches pass through the superior constrictor muscle and divide

Fig. 6.—T. P., tonsilla palatina; A. P. A., A. palatina ascendens; P. T. A., plicata tonsilla anterior; R. T., ramus tonsillaris; M. L. V. P., M. levator veli palatini. (After Toldt.)

on the capsule of the tonsil into numerous ramifying branches, which enter the tonsil along the trabecular bands. In hypertrophied tonsils this artery is sometimes large and may cause troublesome hemorrhage.

(b). The ascending pharyngeal is a small branch of the external carotid. It is a long, slender vessel, deeply

seated in the neck beneath the other branches of the external carotid and the styloglossus muscle. It arises from the back part of the external carotid near the origin of the vessel and passes up to the under surface of the base of the skull, ascending the neck between the internal carotid and the side of the pharynx, lying on the rectus capitis anticus major muscle. It gives off a tonsillar branch opposite the tonsil which passes forward on the superior constrictor muscle, which it pierces and then divides into ramifying branches on the tonsil.

It also sends branches to the Eustachian tube and soft palate. Above the edge of the superior constrictor muscle it gives off the descending palatine which passes under the constrictor muscle and anastomoses with the ramifying branches of the tonsillar or ascending palatine artery (Figs. 3, 4, 5).

(c). The ascending palatine, a branch of the external maxillary, passes up between the styloglossus and stylopharyngeus to the outer side of the pharynx, after supplying these muscles, the tonsil and the Eustachian tube (Figs. 5, 6). It divides near the levator palati into two branches; one follows the course of the tensor palati, supplying the soft palate and palatine glands, the other passing to the tonsils, which it supplies, the branches anastomosing with the tonsillar artery when present and descending palatine branch of the ascending pharyngeal.

(d). The dorsalis linguæ arises from the lingual artery at the anterior margin of the hyoglossus muscle, ascending to the dorsum of the tongue. It supplies the mucous membrane of the tonsil, the palatine pillars and the epiglottis, anastomosing with its fellow from the other side and the ascending palatine or tonsillar artery (Figs. 4, 7, 8).

ANATOMIC RELATIONSHIPS

The tonsil is in relation in front, with the anterior pillar; internally, with the oropharynx; above, with the supratonsillar space; externally, with connective tissue external to which lies the superior constrictor muscle of the pharynx. "The pharyngomaxillary space lies external and behind the tonsil. The "pterygopharyngeal space" is an irregular conical space, more or less triangular in cross section (Fig. 9). It contains a varying amount of fatty areolar tissue, in which lie the ascending palatine and tonsillar arteries. It is bounded externally, by the internal pterygoid muscle; internally, by the wall of the pharynx; posteriorly, it communicates with the fatty tissue of the pharyngomaxillary space which lies adjacent to the posterolateral wall of the pharynx. In the pharyngomaxillary space lie the internal and external carotid arteries, the internal jugular vein with its branches, the vagus and hypoglossus nerves and the styloid muscles. The tonsil rests on the medial side, and is therefore separated by the fascia and fat of the space from the pterygoid muscle and mandible against which it is pressed."

The internal carotid lies backward from the tonsil at a distance of 1.5 cm. and the external carotid backward and outward at a distance of 2 cm. They are therefore separated from the tonsil by the superior constrictor and the stylopharyngeus and to some extent the styloglossus muscle (Figs. 1, 2, 9).

The Eustachian Tube.—The Eustachian tube lies just above and a little behind the tonsil at a distance of 1 to 1.5 cm. and in cases of hypertrophy of the gland

upward and outward it often extends along the course of the tube, causing tubal occlusion or inflammatory reaction by continuity of tissue (Fig. 2). This is a frequent cause of tinnitus aurium.

CERVICAL LYMPHATICS

The tonsil has for its afferent lymphatics the deep branches from the nose and some branches from the tongue. The efferent branches empty into both superficial and deep cervical chains through the peritonsillar glands which lie external to the internal jugular and in close relation to it. (This chain encircles the jugular.) These glands can be demonstrated in children as the glands commonly removed by surgeons for tuberculosis. The lymph from this chain of glands is emptied into the jugular trunk, which, with the lymph from the

Fig. 7.—M. H. G., M. hyoglossus; P. T., tonsilla palatina; R. T., ramus tonsillaris from A. palatina ascendens; A. P. L., A. profunda linguæ; A. L., A. lingualis; A. C. E., A. carotis externa; A. T. S., A. thyroidea superior; A. C. I., A. carotis interna. (After Toldt.)

subclavian trunk, is emptied directly or by means of the thoracic duct into the vena cava. There are numerous anastomotic branches between these glands, and the flow of lymph is not always in one direction. It may flow in any direction, seeking the line of least resistance through these anastomotic branches. This accounts for infection being carried differently at different times. If the current were constant in its direction infection would travel in one direction only.

PHYSIOLOGY OF THE TONSIL

The true function of the tonsil has to do with early life and at birth the gland is so small as to be unimportant. It attains its full development by the sixth or eighth year and then begins to atrophy. By the age

2. Wilson: *Anatomy and Physiology of the Tonsil*, THE JOURNAL A. M. A., May 26, 1906, xlv, 1593.

of twelve or fourteen it has completely disappeared or shows as a hypertrophied or a cicatricial mass between the palatine pillars. Any tonsil which is visible to any marked degree later than this may be considered as a morbid growth due to disease.

It has been stated by some writers that children with adenoids and enlarged faucial tonsils are backward mentally. In a report of examinations of school children those of certain ages were compared both as to the presence of lymphatic growths and the grade obtained in school. It was determined that at the age of six 40 per cent. of children had adenoids and tonsils; those at the age of eight, 32 per cent.; those at the age of ten, 20 per cent., and those who had reached the age of twelve had 15 per cent. Therefore, if children of six years of age be compared with those of eight, we will find 8 per cent. more having adenoids and tonsils than those at eight years. Children at eight years will

Fig. 8.—A. D. L., A. dorsalis linguae; A. L. S., A. laryngea superioris; E., epiglottis; T. P., tonsilla palatina; A. T. I., A. thyroidea inferioris. (After Toldt.)

have 12 per cent. more than those at ten, while those at ten will have 5 per cent. more than those at twelve years. The backward student will have a less percentage than his associate in school who is younger and brighter in his school work. This statement must be modified, however, because students of eight years will be few in number and of these few probably all will show the presence of adenoids and tonsils, which might prove the child with these growths was really backward.

Clinically, nearly all children at six have adenoids and tonsils; at eight, probably 85 per cent.; ten, 35 per cent., and at twelve, about 15 per cent.

It has always been understood that the tonsil was responsible for most of the diseases of childhood and many of the circulatory, respiratory, as well as nervous diseases.

It is probable when the child has a pathologic condition of this structure that all kinds of infections may occur. The tonsil can be infected by cultures applied on the investing membrane and more easily by introduction of bacteria into the crypts where the mucous lining is less of a barrier on account of its thinness. Various infections may be traced to the tonsil as a portal of entry, but this phase of the subject is not in the scope of this paper. Some authors claim the tonsil as a part of the digestive tract, basing their view on the idea that in respiration, unless the gland is pathologically hypertrophied, the tonsil is cut off from the ingoing current of air; because when the mouth is closed in the act of respiration the tongue is pressed back and the posterior pillars contract so that they nearly, if not quite, meet in the middle line. This presses the faucial tonsil against the base of the tongue and covers it by the posterior pillars, so that the ingoing current of air does come in contact with it.

It is said that the lymphocytes pass into the stomach, having escaped from the tonsillar crypt, and in the stomach become the salivary follicles aiding in digestion. It is also said that particles of food are forced into the tonsillar crypt during deglutition and here act as irritants, being partially at least digested in this place, or produce, as a result of their influence on the tonsil, the production of antibodies or antitoxins.

In contradiction to this theory it is found that if pieces of healthy tonsils are ground with water and the solution filtered the fluid produced will have no effect on albumin or beef broth, showing the absence of enzymes in the product of the tonsil, and therefore that the digestive function is *nil*. The same fluid placed in a test tube with typhoid or the commoner forms of germs all have a like turbidity, showing the bactericidal property wanting.

One author has the idea that the endothelium in the crypt undergoes a transformation into lymphocytes which enter the tonsil from without inward, but this has never been proved to the satisfaction of others.

We are told by Stöhr that the true physiologic function of the tonsil lies in the lymphoid nodules. In these nodules the center, which is termed the germ center, breaks down, changing the lymphoid tissue into lymphocytes. These lymphocytes are migratory cells and escape into the crypt in quantity through the mucous membrane lining, and thus find their way to the surface of the gland, carrying with them digested bacteria and effete material—phagocytosis.

It is known that the presence of lymphocytes exercises no influence on bacteria unless aided by some more developed leucocyte. If there is inflammation or infection in a gland it is the function of the eosinophiles to pour out opsonins, after which the lymphocytes will march up in quantity, surround, digest and carry off the residue. It is probable that the eosinophile is a product of some organ other than the tonsil, so the tonsil can not be considered an organ of destruction for bacteria, as it cannot do this without the assistance of some other tissue, probably the spleen or bone marrow in which the eosinophile is formed, which seems essential to the phagocytotic function.

So far as I can learn, the physiology of the tonsil, as we know it, has been limited to the study for the most part of pathologic glands, and has not included the so-called normal tonsil, which marks its decline after the sixth or eighth year.

If the tonsil in a normal state is removed *in toto* there is no disastrous after effect, as in the case of the thyroid. On the other hand, the individual is improved in health; in the young this is simply from the fact that respiration is carried on in a proper way by not being impeded by a mass which acts as an obstruction.

After the age of six or eight years, when the function of the tonsil begins to disappear, the general condition of health is invariably improved by the removal of the gland. It is a common occurrence for these patients to gain one or two pounds a week after removal of the glands. This is produced in one of two ways; first, by the removal of an obstructing mass to respiration; second, by removal of an infecting focus.

It is probable that the lymphatics of the nose, nasopharynx and oropharynx, have some function with the formation of the face and the accessory cavities of the nose, and therefore it appears to me that their function is an ancestral or developmental one. This is reasoned from the fact that they are present *ad maximum* during the time when such changes are taking place. Thus at birth the superior maxilla is only partly formed. The

Fig. 9.—Showing relation of parts after Toldt): A. C. I., A. carotis interna; V. J. I., vena jugularis interna; A. C. E., A. carotis externa; G. P., glandula parotis; M. R. C. A., M. rectus capitis anterior; M. L. C., M. longus capitis; F. P., fascia prævertebralis; M. C. P. S., M. constrictor pharyngis superior; M. S. P., M. stylopharyngeus; M. S. G., M. styloglossus; M. S. H., M. stylohyoideus; M. D., M. digastricus; M. M., M. masseter; S. P. M., spatium pharyngomaxillaris; M. P. I., M. pterygoideus interna; R. M., ramus mandibulae; T. P., tonsilla palatina; A. G. P., arcus glossopalatinus; A. P. P., arcus pharyngopalatinus.

orbit is well formed, as is the mouth, but the mouth lies almost in direct contact with the lower border of the orbit, the rudimentary teeth being the only tissue separating the two cavities. The body of the sphenoid bone is not developed, the sphenoidal sinus being a small cavity not more than 2 or 3 mm. in diameter; the ethmoidal cells are mere depressions in the middle turbinal; the frontal sinus can not be seen, as the two frontal plates have as yet not separated, and the antrum of Highmore is only a small slit 3 or 4 mm. in length, situated between the nasal cavity and the infraorbital foramen, just inward and below the orbit, while the nasal bones are simply small projections in the beginning of formation.

It seems to me that the lymphatics of the nose, nasopharynx and oropharynx were occupied with the process of katabolism after the blood had at least in part finished the process of anabolism. In this manner the

broken-down tissue finds its way into the deeper lymphatics of the nose and from thence through the post-pharyngeal, tonsillar and submaxillary glands into the general lymphatic current. It may also be possible that the tonsils are stimulated by this process into producing some substance which is given to the blood, which in turn regulates some function which is active at this period of tissue formation and absorption.

It is evident that if we are to ascribe any function to the glands it must be one which is active during the first part of the child's life or between the first and sixth or eighth year, at which period the gland has already passed its height of usefulness in the economy and is beginning to disappear by atrophy.

It is claimed that the tonsil, in particular cases, has come to have a function in modulating the voice. This, however, I look on as a mere matter of education, and the singer or speaker would have come to modulate the voice just as well without this gland as with it. On the other hand, we have all seen cases in which voice was increased in tone and volume by the removal of these growths. The richness of quality and volume of tone is often added to 100 per cent. after the enucleation, provided the pillars remain intact and are not bound down or together by cicatricial tissue. I have observed four patients in whom there was loss of voice who were relieved by removal of the tonsils. These individuals are usually affected in one register, more frequently the middle.

The removal of tonsils in the adult can not be studied in this connection, however, as the presence of such growths is a pathologic phenomena.

I still believe that tonsils after the sixth or eighth year of life are pathologic in their character and as such are productive only of detrimental influence in rendering the individual unable to cope with infections of various kinds, and thereby working a hardship to the general economy.

It is true that I am making a rather sweeping statement as regards the function of this gland and one which may bring much criticism by the members of the profession, but it seems to me the investigations so far as published by the various writers are of little value, having been observed from an erroneous viewpoint.

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CONDITIONS OF THE FAUCIAL TONSIL WHICH CALL FOR OPERATIVE INTER- FERENCE*

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The conditions of the faucial tonsil which call for operative interference may be divided into two classes: (1) Simple hypertrophy causing interference with respiration; (2) diseased conditions of the tonsils themselves causing local or constitutional infection.

SIMPLE HYPERTROPHY

While tonsils have been removed from time immemorial—it was certainly done by the ancients—it is only of late years that much study has been given to the evils of mouth breathing and attention drawn to the

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