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BRANCHIAL CYSTS AND FISTULAE

By Leonel Loder
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BRANCHIAL CYSTS AND FISTULAE

The possible flaws which may occur in the process of development of the human individual are countless, yet relatively rare in occurrence. The constancy and uniformity with which nature carries out development is surely far beyond our comprehension. Yet we may observe this process at its various stages and see how an arrest of development at a certain time would give rise to some of the flaws often seen in the mature fetus. Since human embryonic material cannot be procured at will, there are many gaps in the understanding of this ever changing process which must be bridged over by theory. Thus we have a difference of opinion on many of the anomalies brought forth for explanation. Since this paper is to deal primarily with branchial cysts and fistulae, which are the end result of improper development of part of the pharyngeal and branchial apparatus, we shall see that there is still considerable discussion as to the procedure followed by this portion of the embryo in the bringing about of its completion.

The Development of the Branchial Apparatus.

The conception of the branchial apparatus, its actual presence, significance, and development has been one of considerable discussion for approximately the past one hundred years. It being started by Rathke in 1825 when he observed the branchial arches present on the embryo pig. A similar observation was made by Von Baer on the human embryo in 1827. At this time four branchial clefts were described. Additional knowledge has been continuously added to the original observation by, Cussett 1877, Hiss 1881, who was the first to make reconstruction wax models of the human embryo, G.
Born in 1883 who was first to describe the thymus anlage, and others who will be described later, until our present most generally accepted conception of development as edited by Keibel and Mall in 1912 has been reached. Their work has been very effectively worked over and revised in Arey's book on developmental anatomy, from which a brief review of the development of the branchial apparatus will be taken in order that a clearer idea of the anomalies here proposed to be discussed will be thoroughly understood. If, however, Wenglowski's work done in Russia between the years 1907 and 1912 is accepted as authentic then a large part of the present accepted theory of branchial development will be obsolete. The changes which he makes will be pointed out later.

Arey in his 'Developmental Anatomy' gives the following account of pharyngeal and branchial development and their derivatives. The formation of the face and neck is closely bound up with the history of the branchial arches. These are bare like bridges separated by grooves which occur on the lateral surface of the neck visible in the 2-6 mm embryo, disappearing in the 12 mm stage. (Fig. I, Ia and II) These branchial arches are rudiments of the gill arches of the salamanders, but in the human they never assume a respiratory function, instead are only transitory vestiges which are early transformed and applied to various purposes.

The human embryo develops five arches, separated by four ectodermal grooves. Subadjacent to these grooves the entoderm of the pharynx bulges correspondingly as entodermal pharyngeal pouches. Ectoderm and entoderm then unite and the thin closing plate is formed which often ruptures to form a temporary opening. If this opening persists it may be the starting point of either a cyst or fistula.

Towards the end of the sixth week the first two arches which have grown most rapidly, overlap the other three and obscure them. The caudal arches sink into a triangular depression called the cervical sinus. This
sinus is closed off when the second arch fuses with the thoracic wall, thus forming all that is necessary for the formation of a cyst of tumor.

From each of the four mentioned pharyngeal pouches develops small dorsal and ventral sacculations. The first and second pharyngeal pouches of each side soon open into the broad lateral expansion of the pharynx. The third and fourth pouches grow lateral from the pharynx and communicate with the pharyngeal cavity through narrow ducts.

Although these pouches do not continue as part of the digestive apparatus that is the site of their origin (Fig. III). The dorsal wing of the first pouch elongates during the second month into an auditory tube which terminates in the expanded cavity of the middle ear. The ectoderm deepens at the same time to meet it forming the tympanic membrane.

The second pharyngeal pouch during growth and lateral expansion of the pharynx, is largely absorbed in the pharyngeal wall, its dorsal angle alone is believed to persist as the tonsillar and supra-tonsillar fossa. The essential structure of the palatine tonsil is attained in the fetus at five months.

Towards the end of the sixth week the third set of pharyngeal pouches shows signs of ventral sacculations which are set free in the week following. These sacculations, at first hollow, become rapidly solid epithelial strands. Normally their upper ends lag and atrophy. The lower ends fuse and migrate caudally into the thorax destined to be the thymus gland.

The dorsal wings of both the third and fourth pharyngeal pouches, give rise to small masses of cells which at the end of the seventh week become detached from their respective pouch and migrate caudad to take their position behind the thyroid gland as the parathyroid glands. Those of the third pouch undergo the greatest displacement taking their position at the lower poles of the thyroid while those of the fourth stop at the upper poles.

The fifth pair of pouches, the existence of which is disputed, gives
rise to the ultimo branchial bodies which are also questionable and of no consequence.

The branchial arch derivatives are primarily skeletal. The first arch on each side forks into an upper maxillary and lower mandibular process. Cartilage fails to appear in the maxillary processes, due to accelerated development, hence the palate bone develops from a single center of ossification. According to recent investigators two centers contribute to the formation of each maxilla; one gives rise to the portion bearing the incisor teeth, the other to the remainder.

The mesenchymal core of the mandibular process transforms into a cartilaginous bar, Meckels Cartilage, which extends proximally into the tympanic cavity of the middle ear and is there incased by the future temporal bone (Fig.IV). Despite the presence of this ancestral jaw material, it does not ossify into the definitive mandible. Instead, membrane bone, developing distally in the body of the future lower jaw, enclosed both Meckel's cartilage and the inferior alveolar nerve, whereas proximally in the ramus the membrane bone is a plate which merely lies lateral to these structures. This relation explains the position of the adult mandibular foramen where the nerve enters the interior of the jaw bone. The portion of Meckel's cartilage invested by bone disappears and contributes nothing to the permanent jaw which results from the fusion of its two halves, each with a single center. Traced proximal to the mandibular foramen the cartilage becomes in order, the sphenomandibular ligament; malleus and the incus. The mandible changes greatly in shape with growth and acquisition of permanent teeth.

The second arch also enters into relation proximally with the periotic capsule. The upper segment of Reichter's cartilage resolves into the separate stapes as well as the tympano-hyal and styloid process; both of which combine with the temporal bone. The succeeding distal portion of the arch is converted into the stylo-hyoid ligament, it connects the styloid process with the distal end of the arch which also undergoes inter-cartilaginous ossifica-
tion to form an each side a lesser horn of the hyoid bone.

The cartilage of the third branchial arches ossifies and refashions into the paired greater horns of the hyoid bone, while the palate connecting the two arches becomes its body.

The fourth branchial arches differentiate into the cuneiform cartilages and most of the thyroid cartilages.

The fifth branchial arches not only appear to contribute to the thyroid cartilage but are also held to transform into the corniculate, arytenoid and cricoid cartilages.

This theory of development and disappearance of the branchial arches and pharyngeal pouches, and the development of their derivatives is that most commonly accepted by the embryologists. It being the result of a great deal of long and tedious work. For as Dr. Latta says, 'the development of the pharynx and its derivatives has long been a battle ground of evolution.'

Romulad Wenglowski, previously mentioned, who was a Russian surgeon and investigator did a considerable amount of work between the years 1907-1912 in an attempt to overthrow and discount the theory of pharyngeal development just discussed. A complete survey of his work is given by Herbert Meyer in the *Ann. of Surgery*. His conclusions are based on five years of work, studying seventy-five human embryos (ranging from 2-5 mm), and two hundred six cadavers, one hundred forty seven of which were children.

According to His the branchial clefts and pharyngeal pouches coincide in their direction throughout their length and are separated by a thin membrane. This, Wenglowski considers an error. 'In sagittal sections by His, as found in most text books, it is shown that the convexity of the branchial arch coincides with that of the pharyngeal arch, and concavity of the branchial cleft with that of the pharyngeal pouch. In reality, Wenglowski claims this does not occur in the human beings and is only faintly indicated in the three mm embryo where the apparatus is exceedingly simple and early in deve-
ment. In the later stages each branchial arch and cleft crosses the pharyngeal arch and pouch. This is caused by the fact that the mesial ends of the branchial arches and clefts run forward and upward and orally, while the pharyngeal arches and pouches run posterior and downward and aborally. Thus the bottom of the clefts and pouches run in different directions and therefore are in contact only for very small areas where small occluding membranes are present. The contact point between the clefts and pouches occurs in the lateral portions. Therefore, the occluding membrane occurs in the lateral portion of the clefts. The largest occluding membrane is present in the second cleft. 

Wenglowski also states that the lower border of the hyoid, the body of which in his interpretation comes from the 3rd arch, forms the lower border of all the remains of the branchial apparatus, and that in the adult the entire apparatus groups itself, or better, it rests along the lower jaw and around the hyoid and its cornu. He states that, 'at first the region above the hyoid is large and that that appearing later below the hyoid is absent, and right between the second arch and the heart the anterior chest wall will appear. During further development the portion above the hyoid remains almost unchanged. The portion below the hyoid lengthens as the heart descends. The branchial apparatus, however, can influence only the upper neck region, as its position is sharply demarcated by a line drawn through the hyoid bone.'

In other words, in his opinion, all congenital anomalies caused by incomplete retrogression of the branchial apparatus must be located in the region above the lower border of the hyoid bone, and that almost all congenital anomalies of the neck are not the result of the branchial apparatus, but from other factors, even though they may have originated from this apparatus.

It is upon this last statement that he, Wenglowski, bases his whole theory of cervical anomalies commonly known as branchial cysts and fistulæ.
The basis of the statement being the development of the thymus gland.

**Development of the Thymus Gland (Fig. III, IVa)**

In 1831, Arnold found in an eight weeks embryo two passages on either side of the trachea which he interpreted as belonging to the thymus. In 1881, Stieda stated from experiments on sheep and pig embryo that the thymus developed from the third and fourth clefts.

His at first believed that it came from the second, third and fourth pharyngeal pouches. He later changed his mind and in 1886 stated that it came from the depth of the cervical sinus and again in 1889 changed his opinion, believing that it came from the third branchial cleft.

In 1883, Born showed in a pig embryo that the thymus developed from the posterior portion of the third pharyngeal pouch. Hammar found no evidence of the thymus in a 3-5 mm embryo. In the 8 mm embryo he found in the corner of the 3rd pharyngeal pouch a pocket running downward and medially, converging with that of the opposite side. He published a picture of an 18.5 mm embryo in Kollman's Atlas, in which he showed the thymus as a long strand running along side the pharynx and esophagus. The upper gland portion was thickened and from the upper end of the thymus a narrow strand passed upward indicating a connection with the pharynx. (Meyer)(10)

The last view is essentially that upheld by the embryologists today. These ventral thymic sacculations being set free from their pharyngeal attachment during the seventh week or at about the 25 mm stage. The at first thymic prim-ordia rapidly becomes solid epithelial strands and normally the upper ends lag and atrophy.

Wenglowski places a good deal of stress on this thymic anlage. He feels that any portion of the thymic cord of cells may persist and give rise to a cyst or that it may all persist and communicate with the pharynx giving rise to a pharyngeal sinus and at some later date in life rupture to the surface anywhere along its course, which follows the anterior border of the sternomastoid muscle, thus giving rise to a fistula. If this is true it largely
discounts the theory that these anomalies are of branchial origin.

The most commonly known and probably most widely recognized theory as to the origin of such cervical cysts or fistulae is that proposed by Rabl as given by Caro and Stout[5] which places them primarily as branchial anomalies. Rabl's hypothesis is based on the formation of the precervical sinus, within which, as previously described are the second, third and fourth grooves. (Fig.V)

The furrow beneath the second arch is very deep at its posterior end and persists longer than any other of the transitory conditions. The third and fourth furrows gradually become stretched out and flattened to disappear. It is accordingly evident that the level of the second furrow is the logical point at which a fistula may enter the pharynx. With this hypothesis the following anomalies are explained;

(1) The external opening may be high or low in the neck depending on the downward extend of the growth of the second branchial arch (hyoid arch.) In no case would it be above structures derived from the hyoid arch or below the sterno-clavicular joint. The evagination or invagination determines the external opening with respect to the midline.

(2) The blind end of an incomplete external fistula is a continuation of the vestigeal remains of the ectoderm of the precervical sinus.

(3) If the second arch obliterates the precervical sinus, but the second furrow persists and communicates with the pharyngeal entoderm an incomplete internal fistula results.

(4) A cessation of complete downward growth of the second arch accompanied by a break through the mesoderm at the level of the second furrow, will produce a complete branchial fistula.

(5) If both internal and external openings are lacking and the precervical sinus has not been obliterated, a branchial cyst will result.

From what has been presented thus far it may be seen that regardless of which line of thought you wish to follow in regard to the formation of the
cervical cystic or fistulous anomalies you will have plenty of company to back you up. It is true however, that the work of Wenglowski is largely upheld by surgical investigators while the branchiogenic theory is largely backed by the embryologists who spend a life time microscopically working out the details of development.

Disregarding the origin for the present we find that these cervical anomalies have many very constant features. Let us first consider the branchial cyst. Hamilton Baily, probably the most quoted of any one authority on branchial cysts follows the branchiogenic theory and divides cysts into four groups. (Fig. VI)

(1) Those lying just beneath the skin.

(2) Those extending to and attached to the internal jugular vein.

(3) Those passing between and straddling the bifurcation of the common carotid.

(4) Those of the mucous or columnar cell type lying entirely posterior to the common carotid next to the pharynx. The cyst is usually in close relationship with the deep surface of the upper half of the sternomastoid muscle and nearly always protrudes around the anterior border of the muscle. Most commonly the center is opposite the greater cornu of the hyoid bone.

Baily feels that the type of epithelium and character of cyst contents many times indicate whether the origin was in the cervical sinus or in the pharyngeal pouch or both. If it is lined with stratified squamous epithelium and filled with an opaque fluid, often mixed with pus, it is likely to have arisen from the cervical sinus. If, on the other hand, it is lined with columnar or ciliated epithelium and filled with a glossy mucous, it probably had its genesis in a pharyngeal pouch. In many cases the squamous epithelial layer has undergone a process of differentiation with the formation of prickle cells, a horny layer and a sort of papillary arrangement, also sebaceous glands, sweat glands and hair have been found, characteristic of a dermoid cyst.
Another very constant finding under Bailey's examination was cholesterol crystals in the aspirated fluid. This finding, although it does occur in branchial cysts, is not necessarily characteristic of branchial cysts alone for cholesterol crystals are found in the fluid content of most epithelial lined cysts.

Other clinical features besides those just mentioned are given by Carp and Stout. In an analysis of twenty cases it appeared that they occur most frequently in the third decade, although infancy and old age were not exempt. Females were preponderant in a proportion of two to one. In the majority of cases the anomaly was found on the left side. As a rule, the enlargement of the cysts came on gradually, but some alternately diminished and increased in size. The enlargement with recession is probably best explained on an inflammatory basis, for the wall is surrounded by a heavy layer of lymphatic tissue which may become a frequent site of inflammation. Occasionally, in their series of cases the size was constant for a long period of time and suddenly became larger.

Shedden, in making a summary of forty cases at the Massachusetts general hospital states that the tumor does not disturb the patient very much unless some other factor such as pain enters in. For this reason people do not report for treatment as soon as the tumor appears. In their series of cases the average patient allowed the process to develop almost three years before coming to the clinic. The shortest duration was two months and the longest twenty years. The tumor was found to be slightly more common on the right side where as Carp and Stout reported theirs as being more common on the left. No cases of bilateral cysts have been reported.

When a patient presents himself with a tumor of this nature several things must be thought of and ruled out in making a diagnosis. Shedden states that it is not difficult to make a diagnosis if one is confronted with a unilateral cystic tumor in the mid or upper portion of the lateral aspect of
the neck. If, however, we keep in mind that any cervical mass high or low, firm or soft, and even when accompanied by lymph nodes may be a branchial cyst, a correct diagnosis will be made in a high percent of cases. Correct preoperative diagnoses were made in over half of their cases.

Several other things must be thought of in making a diagnosis. (22)

(1) Tuberculous lymph nodes are the most common mistake made in diagnosis. The presence of cervical lymph nodes accompanying the mass in question suggests tuberculosis, but unfortunately this does not rule out branchial cyst, for in twenty-nine per cent of Shedden cases cervical nodes were present. A very helpful aid in making this differential was offered by Owen Wagsteeen of Minneapolis. The tumor is aspirated through an hypodermic needle with subsequent injection of a fluid opaque to X-ray. The finding of a sharply circumscribed limitation of the opaque injection medium on an X-ray film is pathomonic of a cyst. In the presence of a tuberculous or cold abscess which has given rise to suppuration from such as a tuberculous spondylitis, the opaque medium will be seen to dissect along natural tissue planes in an irregular fashion. (25)
(2) Dermoids occur occasionally in the parotid region from remnants of epidermis left during closure of the first branchial cleft and might be found anywhere that a branchial cyst may be found.

(3) Lymphangioma of cystic type (cyst hygroma) is translucent, while the branchial cyst is usually opaque. Lymphangioma rarely occurs after the age of five years. It is most frequent at the time of birth and usually occurs above the clavicle at the lateral border of the sterno-mastoid muscle. Surgery is often employed but irradiation is the treatment of choice.

(4) Thyroid cyst can usually be identified as being attached to that gland when the patient swallows, but an aberrant lateral thyroid cyst might be confused with a branchial cyst.

(5) Venous hemangioma may be ruled out by putting pressure over the enlargement. If it is an hemangioma it will empty, if branchial it will not. When making pressure however, it must be remembered that a branchial cyst being pushed in the retro-pharyngeal space will give this same impression of emptying.

(6) Retro-pharyngeal abscess is usually ruled out by aspiration.

(7) Thyroglossal cyst need not necessarily be in the midline. Microscopically it may be impossible to differentiate a branchial from a thyroglossal cyst.

(8) Lipoma is rare in the neck and is not often confused as its texture and consistency are characteristic.

(9) Tumor of the parotid is in most cases an encapsulated, firm, elastic, nodular, and lobulated mass. It may, however, be very soft and composed largely of mucoid tissue, which may ultimately liquify. Location may be used here as a differential. Tредет has, however, described an intraparotid branchial cyst evidently arising from the first cleft.

(10) Ranula will usually occupy as a whole or in part the submaxillary triangle.
Cystic degeneration of a malignant neoplasm is very rare, and it is also rare for a branchial cyst to make its first appearance at carcinoma age.

Myxomatous degeneration of a mixed parotid tumor is a pathological curiosity.

The untreated branchial cyst is subject to a few complications:

1. Inflammation occurs occasionally in the unaspirated branchial cyst and becomes the seat of repeated attacks of a subacute inflammatory process which gives rise to pain, swelling and occasionally suppuration.

2. An acquired fistula will usually result if a branchial cyst is either accidentally or intentionally incised.

3. Branchiogenic carcinoma in some clinics is a recognized diagnosis. Its existence however in the opinion of many is not proven. Sir John Bland Sutton states that carcinoma arising in remnants of branchial clefts is pure fiction. Branchiogenic carcinoma should be kept as a diagnosis of last resort. Mouth, nasopharynx, extra pharyngeal recesses and external auditory canal must first be searched for primary growth.

Before the treatment of branchial cysts is considered let us return to the extensive anomaly - the branchial fistula. In order that the symptoms of such an anomaly be properly evaluated a more complete detail of the course of the tract in relation to other structures is important. Shedden gives the topography as follows. A fistula of the 2nd branchial pouch or cleft, the most common, is covered with skin, superficial fascia, platysma muscle and the superficial layer of the deep fascia of the neck. It courses along the medial border of the sternomastoid muscle to the greater cornu of the hyoid. Thence, it passes superficial to the common carotid, over the carotid bifurcation and between the internal and external carotid arteries and ventral to the 9th and 10th cranial nerves. It is often in close relationship with the internal jugular vein. At the level of the greater cornu of the hyoid the fistula takes a turn medially and dorsally and thus, at
this point, probing is often blocked. Passing beneath the digastric, it enters the lower pharynx or posterior palatine arch near the tonsil. In its course it runs near the 9th and 12th nerve.

To get the reason for such a constant relationship of the tract to vessels and nerves we turn again to embryology. In the human embryo the ventral aorta gives off aortic arches which pass dorsally up each visceral arch. A fistula of the second cleft is found to run between the first and second aortic arches, which later become the external and internal carotids. The common carotid develops in conjunction with the 3rd branchial arch. A fistula of the 3rd cleft lies between the common carotid and the vagus. A fistula of the 4th cleft would bend around the innominate artery on the right and the right and the arch of the aorta on the left. Any departure from this arrangement is not possible if the vessels are normal. The precervical sinus is superficial to the carotid vessels and its opening is in front of the sternomastoid at a low level in the neck. (Shedden)

As for relationship of the tract to nerves, Carp places added emphasis upon the close proximity of the tract with the various cranial nerves. This is brought out very clearly in a case report by him which will be reviewed later. The manner in which these various nerves come into contact with the tract is explained by a review of the relation of the various nerves to the arches, as given by Carp. "The facial nerve is distributed along the inferior border of the first arch and the superior border of the second. The glossopharyngeal nerve courses along the inferior border of the second and the superior border of the 3rd arches. (Husley) The superior laryngeal branch of the vagus supplies the 4th arch, and the vagus itself pass behind this arch to descend into the thorax. (Quenu) (Fig. VII)"

By reason of their location, these nerves, especially the 9th and 10th may be affected by irritations from inflammatory changes in the tract, undue pressure from retained secretion, or sudden pressure produced by an instrument.
It is also possible that these nerves might send aberrant branches to the wall of the tract. Thus, Tourneux speaks of the muscular fibers of a fistulous tract being rich in nerve filaments of the glosso-pharyngeal. Watson, in dissecting a cadaver, found a complete branchial fistula which intervened between the stylopharyngeus muscle and the glosso-pharyngeal nerve, which normally, are in close apposition. As it passed behind the fistula, the glosso-pharyngeal gave off several small twigs to its walls. In connection with this, it should be noted that most external fistulous openings are along the anterior border of the sternomastoid just above the sternoclavicular junction, and as a result contact with the vagus is probable. (Carp)

The effect of such contact can be appreciated only by a knowledge of the anatomy and physiology of the vagus. In the neck it gives off the superior cardiac branches which arise somewhere between the superior and inferior laryngeal nerves. The inferior cardiac branches arise near the origin of the inferior laryngeal and some of these branches may spring from it. Both superior and inferior cardiac branches pass toward the heart and unite with the cardiac branches from the sympathetic chain to form the cardiac plexion. The last lies on the arch and the ascending part of the aorta, and the inhibitory fibers to the heart have their origin in it. The superior laryngeal nerve sends sensory fibers to the mucous membrane of the pharynx. The vagus itself distributes to the lungs two kinds of sensory fibers—inspiratory and expiratory, which act normally on the respiratory center. Gastric motility and motility of the small intestine and part of the large intestine are partly governed by vagal action. The pancreas and gastric glands receive secretory fibers from it. (Carp)

The intimate anatomical relationship that a branchial fistula may assume with respect to the vagus might, therefore, cause different degrees of irritation. This might further be enhanced by such factors as inflammation, over-destruction of the tract with secretion, instrumentation, or manipulation and the selective vagal fibers which are affected would produce symptoms such as
a cough, hoarseness, acceleration of the pulse, extra systoles, alteration of cardiac force, or gastro-intestinal symptoms.

The presence of the fistulous tract is usually discovered early. The external opening may be present at birth or may appear later in life. Most frequently they first become evident at the age of two or three years. The external orifice is usually small 1-3 mm in diameter. Varying quantities of serous or purulent fluid may escape from this opening, this discharge may be the only symptom present, and may be so annoying that it causes the patient to seek surgical relief. The external orifice may close for a time, days, weeks or even years. There may be a swelling on the side of the neck due to retention of the fluid but this is infrequent. (Kramer)

The internal or pharyngeal orifice may also be the site of discharge, the patient not infrequently comes complaining of a disagreeable taste as the result of the presence of pus or decomposed food. The internal opening of the tract has in several cases made its first appearance following tonsillectomy, thereby exposing the fossa, and either opening the proximal end or permitting the entrance of infection into the tract so that the presence of the tract is made obvious. (Kramer)

Treatment of both Cysts and Fistulae.

Several methods of procedure have been followed in an attempt to obliterate such a tract and a few cases have been reported as having healed spontaneously but the only sure treatment both in cysts and fistulae is surgical excision.

Several things are to be thought of when removal of a branchial cyst is contemplated. Dr. Wagsteen says that at time of operation a large amount of lymphoid tissue and other structures will be found to closely adhere to the cyst wall and that such findings should not be allowed to mislead the operator. The proximity of the cyst with the internal jugular vein, spinal accessory, glosso-pharyngeal, hypoglossal and vagus nerves and the fact that it often passes between the internal and external carotid arteries is of marked importance. This may be seen by the study of the normal anatomy of this region. (Fig. IX, X, XI)
The technique of the operation is described by Hamilton Bailey. A branchial cyst should be completely removed by dissection. It may be conveniently exposed by a transverse incision following the creases of the neck. Except in small, superficial cysts it will be found best to divide the sternomastoid muscle. Beneath this muscle the spinal accessory nerve will be found bearing a constant posterior relation to the cyst wall. The nerve should be isolated.

Branchial cysts often run deeply into the neck, and may extend upward as far as the base of the skull. In this respect they resemble an iceberg, for the greater bulk of the mass is beneath the surface. It is most important and desirable to remove the cyst intact. If the cyst bursts half way through the operation dissection is rendered difficult, surrounding structures are endangered, and the end result may prove unsatisfactory, for even a small piece of secreting epithelium left behind may give rise to a sinus which persistently discharges. Complete dissection of an intact cyst is almost always possible and the operation is very much simplified if the following technique is adopted.

After carefully cleaning the superficial aspect of the cyst about half of the contents is removed by aspiration. The puncture hole thus made is covered by a piece of gauze about the size of two postage stamps. The gauze and the cyst wall are picked up with a pair of sponge-holding forceps. The gauze minimizes the leakage and prevents the forceps from slipping. Gentle traction may be made with the forceps, at first in this direction and then in that, and the cyst wall is cleared by gauze and blunt dissection, aided here and there by a few touches of the scalpel. As the dissection proceeds and the deep parts of the cyst are freed it will be found convenient to apply a second pair of sponge-holding forceps. Using this means an intact cyst may be enucleated.

The care of cervical fistulae includes a rather wide variety of procedures. With the idea of destroying the lining of the fistulous tracts, numerous substances have been injected into them. Iodine, alcohol, caustic potash,
trichloracetic acid, mercuric nitrate, and croton oil have been employed. More than once these substances have passed into the patient's throat and a fatal outcome resulted therefrom. Electrolytic destruction was tried as early as 1865 by Lefort, and Lechwitz who reported a case cured by this method. Electrocautery has been successfully used by many. (Shedden)

Hofer treats the tract with diathermy (Electrocoagulation). He inserts a fine electrode into the fistula, the cauterizing current is turned on and the epithelium destroyed. He reports seven cases successfully treated by this method. (Shedden)

In 1891 Sachs first suggested extirpation and it is the consensus of opinion among surgeons today that radical extirpation is the most effective therapy. (Shedden)

Various surgical procedures have been employed in excision of lateral cervical fistulae and no one operation can be recommended to the exclusion of others. The technique consists primarily in following the fistulous passage so far as possible.

von Hacker passes a probe bearing a piece of ligature through its eye by way of the fistula into the patient's mouth. After the ligature is fastened to the dissected external end of the fistula, the tract is inverted into the pharynx. Here the fistula is ligated and cut off. (Shedden) (Fig. VIII(a,b,c))

Koenig has devised an operation for adherent fistulae. By his technique the duct is dissected free toward the pharynx so far as possible and then incising the mucous membrane of the pharynx, the stump is drawn into the throat, so that both ends of the tract are within the pharynx. (Shedden) (Fig. VIII c)
Six cases have been chosen to illustrate several of the points brought out during the course of this paper, three of Branchial Fistulae and three of Branchial Cysts.

The first case is that which was previously referred to in this paper as illustrating irritation of the vagus by a Branchial Fistula. It is reviewed from an article by Louis Caru on 'Branchial Fistula - Its Clinical Relation to Irritation of the Vagus.' Found in Surg. Gyn. - Obst. 42:772-773. The case is as follows -

A. S., schoolboy, American, referred by Dr. Manahan, aged 5, gave as a chief complaint a discharging sinus in the right side of the neck.

When the child was born, the mother noticed in the front part of the right side of the neck a small, reddish, raised area, about the size of the head of a pin. She paid no attention to it until 2 years ago, when the swelling opened and discharged a small amount of mucoid material. After that time the opening in the neck closed and opened intermittently, the discharge being more profuse when the child had a cold. Occasionally a small swelling formed about the opening. For 2 years the boy had a dry, hacking cough, which was more pronounced at night, and when the sinus was not discharging.

The child was of breech birth and was breast fed. He had bilateral otitis media in infancy. Tonsils and adenoids were removed 1 year ago to cure his cough but without any remedial effect. He had chicken-pox 2 years ago. The family history is negative.

Physical examination showed the patient active and not acutely ill. He wore glasses for slight strabismus. Ears, nose, throat, larynx, heart, lungs, and extremities were negative.

Surgical condition: In the right cervical region, at the anterior border of the sternomastoid, about 3 centimeters above the sternoclavicular junction,
was a soft, non-tender, fluctuating reddish, cystic mass, 3 millimeters in
diameter, with a red dot in the center, which was closed. The cystic mass
became a little larger on coughing. No attempt was made to probe, or to
inject any fluid into it to determine its course or patency. A diagnosis
of branchial fistula was made and operation advised.

Operation, May 7, 1923. Ether anaesthesia.

An incision 3-5 centimeters long was made over cystic mass excised.
There was a distinct tract which went through the platysma, the sheath of
the sternomastoid, and the carotid sheath, between the nerve. It was in
intimate contact with the vagus for a short distance, and slightly adherent
to it at one point. It then coursed obliquely upward and backward toward
the pharynx, but a probe in the tract could not demonstrate an opening into
the pharynx. The pharyngeal end was very thin and friable.

The sinus tract was carefully dissected out by blunt and sharp dissection,
after the sternomastoid, carotid artery, and internal jugular vein
had been retracted. At the pharyngeal end, the tube tore off. The remain-
ing tissue was carbolized. Plain catgut was used to close the platysma and
fascia; subcuticular plain catgut for skin.

The specimen is 3 centimeters in length and ½ centimeter in diameter.
The outer surface is uneven and the cut surface shows a lumen containing
mucoid material surrounded by an elastic wall. The microscopic examination
shows a tubular structure lined by stratified flat epithelium. There is a
marked subepithelial inflammatory cell infiltration. The surrounding muscle
tissue is markedly oedematous.

Progress notes: The cough stopped on the day of operation and the
wound healed by primary union.

Follow-up notes: December 3, 1923. The wound is hairline in character.
There has been no recurrence of swelling, discharge, or cough.

May 10, 1925. End-result excellent. No cough.

November 10, 1925. No recurrence. No cough.
CASE REPORTS

The second case is that given by Wooden and Hutchens in an article 'Bilateral Complete Cervical Fistulae' found in the American Journal of Surgery 3:377

Case No. 32701, Rochester General Hospital.

A boy, aged seven years, was brought to the Out-Patient Department because of a constantly "dirty neck." Since birth the typical lateral openings had discharged thin material, especially at meal time, and had necessitated the wearing of dressings. A period of blocking and cyst formation had never been experienced. A probe could be passed into each sinus about 3 cm., mastication of a methylene blue tablet brought prompt appearance of the color externally, and an injection of bismuth in olive oil permitted a fair outlining of the tract by roentgenogram. There was nothing of importance in the physical examination or family history.

On November 18, 1925, complete extirpation was done on the right side under colonic ether anesthesia. The above-mentioned anatomical relations were defined and the tract was dissected free with some difficulty to within 1 cm. of the pharyngeal entrance. After prolonged and vain search for the inner opening the ligated end was forced through the pharyngeal mucosa at a point presumed to be near the natural opening, and sutured to the posterior pillar. An uneventful recovery was made, leaving a satisfactory scar externally and no trace internally.

After a period of delay due to a series of routine throat cultures exhibiting Klebs-Loeffler bacilli, an identical procedure was carried out successfully on the left side on January 20, 1926.

On follow-up visit one year and a half later, this case exhibits a very satisfactory cosmetic and anatomical cure.
CASE REPORTS

The third case of Branchial fistula is that given by Carp and Stout in an article 'Branchial Anomalies and Neoplasms.' Found in Ann. of Surgery 87.

Hospital No. 69188 Age, eight; sex, female; occupation, school-girl. Ante-operative duration, congenital; side, left. Previous operation, none.

Symptoms and Signs.- At birth small opening just to left of midline in lower part of neck. Since tonsillectomy five years ago had discharged "pus." There was a sticking pain locally and on swallowing. There was slight swelling around opening when it closed. There was about one-half teaspoonful discharge a day. Opening just below level of cricoid along anterior margin of sternomastoid. Tract could be felt a few centimetres under skin upward. No opening in pharynx.

Operative Findings.- Fluid in injected sinus came out in pharynx. The tract extended upward beneath tendon of digastric muscle and hypoglossal nerve and then dipped down to pharynx. The tract was dissected out to this point. Stump carbolized and sewn over. (Dr. Frank L. Meleney.)

Pathology:- Elongated mass of purplish tissue 5.5 cm. in length. At one end was an elliptical piece of skin with a 2 mm. opening in the centre. The wall of the tract was white and 1 mm. thick. Tube surrounded by thin layer of fibrous tissue in which were patches of lymphoid tissue and directly outside of this striated muscle. In one part the tube was lined by stratified squamous epithelium and near the pharyngeal end by stratified columnar epithelium.

Remarks.- Complete fistula.

Result.- Seven months-no recurrence.

The following three cases of Branchial Cysts are again taken from Carp and Stout in their article on 'Branchial Anomalies and Neoplasms.' They give a synopsis of twenty cases of Branchial Cyst.
CASE REPORTS

1) Hospital No. 43364; age, fifty; sex, male; occupation, fireman.
Ante-operative duration, twelve months; side, left. Previous operation, none.

Symptoms and Signs.—Gradual increase in size of swelling 5x8 cm. A soft ovoid fluctuant, movable, encapsulated non-tender mass, anterior to and beneath sternomastoid. X-ray showed shadow in soft tissue.

Operative Findings.—A deep purple cyst, 5 cm. in diameter, lay along the anterior margin of the sternomastoid muscle close to the carotid sheath and beneath the angle of the jaw. Excised without rupture. (Dr. John M. Hanford)

Pathology.—Cyst contained a greenish-purple sticky fluid. There was a great deal of lymphoid tissue in the fibrous wall but no epithelial lining could be demonstrated. There was a lymph-node with the cyst.

Result.—Two months no recurrence but paralysis of depressor labii inferioris. Twenty-seven months no recurrence, paralysis gone.

2) Hospital No. 55161; age, twenty-six; sex, male; occupation, letter carrier. Ante-operative duration, three-fourths months; side, right. Previous operation, none.

Symptoms and Signs.—Gradual increase in size of swelling. Sometimes size diminishes. Soft, fluctuant swelling 3.5 x 4.5 cm. deep to sternomastoid, movable on deeper structures and under skin.

Operative Findings.—Thick-walled cyst, 5 x 2.5 cm. beneath sternomastoid lying on internal jugular vein, slightly adherent to surrounding structures by fine connective-tissue strands. Cyst dissected out easily. (Dr. John M. Hanford)

Pathology.—Wall varied from 1 to 1.5 mm. in thickness and consisted of dense layer of connective tissue, lined with stratified squamous epithelium 3 or 4 cells deep. Within the connective tissue are mounds of lymphoid tissue.

22.
CASE 2.

Contents thick, pearly and gelatinous.

Result.—Eight months no recurrence.

Hospital No. 62618; age, twenty-one; sex, male; occupation, student.

Ante-operative duration, seven months; side, left. Previous operation, none.

Symptoms and Signs.—Gradual increase in size of swelling. One month ago had pain on swallowing for one day. In upper deep cervical region cystic swelling beneath sternomastoid 10 x 8 cm. Freely movable.

Operative Findings.—Well encapsulated fibrous-walled abscess containing 30-40 c.c. odorless creamy yellow pus. Slightly adherent to surrounding structures. (Dr. John M. Hanford)

Pathology.—Cavity lined with necrotic material and with squamous epithelium. Great deal of lymphoid tissue in thick connective-tissue coat. Many lymph-glands with it showing no evidence of tuberculosis.

Result.—Thirty-six months no recurrence.

Remarks.—Pre-operative and operative diagnosis were cold abscess.
CONCLUSION

I. There is considerable discussion as to the exact origin of lateral cervical cysts and fistulae, but the theory most commonly accepted, I believe, is that they are the result of an anomalous development of the branchial arches, clefts and pharyngeal pouches.

II. Although branchial cysts and fistulae are not of common occurrence and as a rule not serious as far as life is concerned when they are present, they are important from a diagnostic standpoint and the understanding of their development gives a clue as to their extent and prognosis.

III. Complete excision of either branchial cyst or fistula brings about complete cure and is the most satisfactory method of treatment.
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   Complete Branchial Fistula - Ann. of Surg. 37: 56-64
   Aug. '03

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28. Whiteford, Hamilton - A Case of Complete Branchial Fistula
   in an Adult - Lancet 2: 818 '15

29. Wooden, and Hutchens - Bilateral Complete Cervical Fistulae -
Fig. I. Human Embryo of 26 mm. (Hiss)
Illustrating Branchial Arches and grooves.

Fig. II. Human Embryo of 12 mm. (Prentiss)
Hence Arches and grooves have lost their identity.

Fig. III. Diagram of Pharynx and its derivatives
(adapted by Prentiss)
Fig IV Meckel's Cartilage and Derivatives of Branchial Arches (Kollmann)

Fig IVa Wax Model of Thymus (Wanglawski)

Fig IVb Schematic Cross Section After Robl. Showing Predominating Second Arch, Prevascular Sinus, and Path of Complete Branchial Fistula (Robl)
Just beneath the Cervical Fascia at ant. border of the Sterno-Mastoid Muscle.

Cyst passes down to and lies on the great vessels. The wall has to be carefully separated from the Int. Jugular vein to which it is firmly adherent. This variety appears to be most common.

Cyst extends inward to the lateral wall of the pharynx, through the bifurcation of the carotid artery. In addition a prolongation of the cyst passes upward as far as the lateral mass of the atlas, and even to the base of the skull.

Columnar lined cyst next to the pharyngeal wall.

Figure VI (Bailey)
Fig VII Sketch Showing the relation of visceral arches, and nerves and blood vessels
Superimposed.

Figs VIII a,b,c - 1, 2, 3 Show Method of von Hacker by inverting duct with a probe.  
4 Shows Koeing's Method of leading duct around tonsil when adherent.
Fig X