

5. THE RELATION OF LYMPH TO METABOLISM.—This relation was indicated, in general terms, under the definition of lymph. As stated above, the lymph is the medium through which every active cell gets its food and its oxygen; it is also the medium into which every cell throws out the waste matter resulting from its metabolism. When we say that lymph is formed by filtration from the blood and modified by osmosis with the blood, we cover the ground of the initial formation of lymph; we must, however, not forget that the lymph is being continually modified, during the time when it is within the several tissues and organs, by the metabolism peculiar to the respective tissues and organs. The blood plasma which filters into leg muscle, intestinal mucosa, and liver is essentially the same in each case, differing only in the respective proportions of proteid, conditioned upon the varying permeability of the capillary walls in these three localities. But the metabolism in these three regions is very different—different not only in respect to what the cells take out of the intercellular lymph, but different also in respect to what the cells throw out into this lymph.

The cells of the muscle will take up fat, dextrose, and proteid from the lymph and throw out various midproducts of proteid catabolism.

The cells of the intestinal mucosa will make no important drafts upon the lymph; they will, however, absorb great quantities of fat, associated with sodium carbonate (Setchenow<sup>32</sup>), and, according to Colin<sup>33</sup> and to Asher and Barbèra,<sup>34</sup> considerable quantities of proteid; and this fat and proteid will be poured into the lymph (chyle).

The cells of the liver will absorb from the lymph not only food and oxygen for their sustenance, but also large quantities of material which represents the midproducts of tissue metabolism. The liver is the great central laboratory of the body where urea, uric acid, bilirubin, and biliverdin are made; where dextrose is taken up from the portal system and changed to glycogen in which form it is stored. To accomplish this, great modifications will be made in both the blood and the lymph which traverse the liver. Of the two fluids the lymph suffers the more profound change.

It must not be forgotten that wherever blood and lymph are separated by a capillary wall osmotic action proceeds, and there will be a modification of both fluids with a tendency toward equalization. The circulation through the liver not being a rapid one, the diffusion of substances between blood and lymph will be considerable. Urea is thrown out into the lymph by the liver cells, and a small part is diffused into the blood. The rest, according to Wurtz,<sup>35</sup> amounting to about 0.016 per cent. of the lymph, makes its way along the thoracic duct, where it is all poured into the venous system and carried presently to the kidneys for excretion.

The lymph contains various substances whose presence and whose relation to metabolism are not understood. There are glycogen and a diastatic ferment,<sup>36</sup> and there is rennet,<sup>37</sup> besides various other substances in traces.<sup>38, 39</sup>

Ransom<sup>40</sup> found that when the toxin of tetanus was injected into the blood not more than one-third of it ever found its way into the lymph. Similarly when tetanous antitoxin is injected it is retained to the amount of two-thirds in the blood.

6. THE MOVEMENT OF LYMPH.—Frequent mention has been made of the flow of the lymph. Let us now consider what it is that causes the lymph to flow.

Like the veins the lymphatics are thin-walled and provided with valves; like the veins the lymphatics are filled from the capillaries by force from the heart, the difference being that the heart forces the blood in a million of capillary streams into the veins, while it forces the plasma of the blood in many hundred million streams through the pores of the capillary wall into the lymphatics.

The initial and principal force which causes the lymph to flow is the *vis a tergo* from the heart, which pushes it on farther and farther from the tissue among whose cells

it escaped from the capillary. As it moves forward it is gathered into the lymph radicles; these in turn are tributary to the smaller lymphatics. Once the lymph reaches a lymphatic there is no retreat because the valves block all backward flow.

The heart force alone would be sufficient to cause the lymph to flow throughout its system of vessels and back to the subclavian vein. There are two forces, however, which are of great importance in assisting this flow. These forces are the negative pressure of the thorax, and the positive pressure exerted upon the blood and lymph vessels by contracting muscles.

Every one is familiar with the influence of negative intrathoracic pressure upon the flow of blood in the veins. Its influence upon the flow of lymph is as important as that upon blood. These fluids are actually pumped into the thorax as water is lifted by a suction pump. Furthermore, the downward movement of the diaphragm makes positive pressure in the abdominal cavity at the same time that it makes negative pressure in the thorax. Thus there is exerted on the lymph in the abdomen both a *vis a tergo* and a *vis a fronte*.

Besides this force exerted by the respiratory movements there is a pressure upon the sides of veins, of lymphatics, and of arteries within contracting muscles. The arteries can by their thicker walls resist this lateral pressure, but the contents of the veins and lymphatics are forced forward—backward movement being made impossible through the closure of the valves.

Hewson<sup>41</sup> believed that lymph was kept moving in the lymphatics by peristaltic movements of the walls of the lymph vessels; but there is no reason to believe that any such movement takes place in any of the higher animals.

The rate of lymph filtration and flow has been investigated by Tschirwinsky.<sup>42</sup> By injecting salicylate of sodium into the blood or lymph stream the time required for it to appear at the upper end of the thoracic duct could be accurately determined. With this method he was able to show: (1) that it required from four to seven minutes to pass from the descending aorta to the thoracic duct; (2) that it required from two minutes ten seconds to three minutes to pass from the femoral artery to the pedal lymphatic; (3) that it required one minute twenty seconds to flow from the pedal lymphatic to the thoracic duct; (4) that it required from thirty seconds to one minute to filter through the tissues.

The flow of lymph seems to be without direct nervous control, though Spallitta and Consiglio,<sup>43</sup> by inducing high pressure in the thoracic duct, observed an increase of blood pressure, and slower, stronger heart beat, which suggested a reflex response to change in the lymph pressure. This points to the probable presence of afferent nerves from the larger lymphatics to the cardiac centres in the medulla.

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LYMPHANGIECTASIS.—It might with propriety be expected, from the analogous process in the blood-vessels, that dilatation distal to the obstruction of the lymph vessels would occur with equal regularity. Such a sequence is a common event with interference of the venous current. In the lymph vessels dilatation rarely takes place from simple hindrance to the circulation, and it is quite universally agreed that the anastomoses in this set of vessels are so abundant that a collateral circulation is readily and speedily established after blocking of one of the branches.

Interferences of the circulation in the larger branches, however, may result in disturbances that attract attention; they may be of a transitory nature like the edema of the arm that surgeons become familiar with, following dissection and removal of the lymph glands of the axilla in cases of carcinoma of the mammary gland; or the symptoms may be of a persistent and serious character, as it is, for example, in the chylous ascites that occurs from obstruction of the thoracic duct. The adult forms of filaria are said to lodge in the larger lymph and chyle passages and cause, among other symptoms, the appearance of chyle in the urine.

Dilatation of the finer branches of the chyle-carrying vessels is readily detected in the lining of the small intestine, during the gross examination, by the fine tracery of whitish or silver-like anastomosing lines and small flat retention cysts with rounded margins, that yield a milky fluid when broken or sectioned; all are very superficially located in the mucosa and are not removable by a stream of running water.

To consider dilatation of the lymph vessels apart from its chief and most important result, elephantiasis, leads naturally to recording unusual and rare conditions of much less importance. Not all accidents, operations, and pathological conditions that interfere with the circulation in the lymph vessels are followed by elephantiasis; in fact, such a sequel is uncommon. Yet when it does occur, it is quite generally ascribed to obstruction of the lymph channels. On the other hand, the clinical history of many cases of elephantiasis denotes an infection that is often unconnected with operations or other mechanical factors which would interfere with the return flow of the lymph. In these cases repeated attacks characterized by chills that are followed by fever, with swelling, itching, and redness of the growing part, have led to the employment of such terms as "recurrent erysipelatous lymphangitis," "erysipèle à répétition," etc.

It does not seem out of place to question the occurrence of elephantiasis without a primary infection, as

well as the rôle in its etiology played by obstruction of the lymph channels; at least the extent to which these factors operate, singly or together, is worthy of consideration and investigation. It is not unlikely that the obstruction is secondary to the infection in many cases and that the recurring cellulitis is to a large degree responsible for the hyperplasia of tissue constituting the main element in these singular cases. In other instances the infection occurs following operations which interrupt the continuity of the lymph channels.

Hamann has observed cases of elephantiasis following extirpation of the inguinal lymph glands. One case described in detail occurred in a woman from whom the glands were removed during the dissection of the sac in a femoral hernia. Six weeks after the operation and three after her recovery, chills and fever accompanied by swelling and redness of the labium majus on the same side occurred, and during the following four months seven or eight similar attacks were experienced. During each attack an increasing brawny induration of the labium took place. The diagnosis was made of lymphangitis accompanied by lymphatic edema due to interference with the flow of lymph, produced by removal of the fat and lymph glands and the succeeding cicatricial contraction. Hamann was at a loss to account for the absence of suppuration. There is small room for doubt that in cases of this kind infection, added to the interruption of the lymph current, brings about the hyperplasia of the subcutaneous tissues, constituting elephantiasis. Other operators have had similar undesirable consequences following removal of the lymph glands and have abandoned extirpation for incision and curettage.

Other cases of elephantiasis with recurring symptoms denoting infection, with each of which there is a progressive enlargement of the affected region not unlike erysipelas, are entirely unassociated with operative procedures. If obstruction to the lymph currents are present in such cases, it may be that they occur early in the course of the lymphangitis. In some of these cases papular eruptions accompanied by an intense pruritus are noticed early.

Whether a cause or a result, lymphangiectasis is a constant feature of true elephantiasis. The enlarged lymph vessels are noticeable in all regions from just below the epithelium—on microscopic examination—to deep within the hyperplastic corium and subcutaneous tissues; they contain no red blood corpuscles, but are found adjacent to the arteries and veins. The arteries are frequently the seat of an endarteritis, obliterative in character, and around all the vessels collections of the so-called round cells—many of which are plasma cells—occur. Dilated lymph vessels are not especially numerous and the structure of the tissue is usually dense fibrous tissue.

There is a very close connection between lymphangiectasis and certain forms of lymphangioma. The definition given by Senn for a lymphangioma is "a tumor composed of lymphatic vessels produced from a matrix of angioblasts." He construes the vessels as newly formed. The proliferation of lymph vessels as a result of inflammation or of even mechanical obstruction of the current must be looked upon as a process of regeneration. The lymphangiomas of the neck, which are usually cystic and congenital, occur in the region of the large lymph channels and are believed to arise from congenital anomalies in them. The lymph collects in them because they are disconnected from the proximal vessels and lymphangiectasis may be said to be present. If, however, proliferative processes are found, as, for example, were present in a case described by Tilger, the lesions are by many authors counted as tumors. It might be possible to consider these proliferative processes, consisting usually of a multiplication of the endothelium, as regenerative in nature, but abortive.

In Wegner's classification of the lymphangiomas, the tumors of one group are said to have their origin in obliteration of efferent lymph vessels through compression, inflammation, or congenital anomalies. Such forms of

lymphangiectasis, if grouped with tumors—lymphangioma—must be clearly separated from the forms in which the essential process is the production of new lymph vessels. The cystic dilatations of lymph channels in the neck, that are virtual retention cysts resulting from maldevelopment in these channels, may form chains of sacs, large and small, lying along the internal jugular vein and other great vessels, and sometimes extending from the mediastinum to the cavity of the mouth. Their dissection is laborious.

Similar retention cysts or localized dilatations of the lymph vessels, and also described as lymphangioma, have been found in the mesentery. Weichselbaum has reported one under the name of chylangioma from its milky or chylous content. In an incarcerated omental hernia at the femoral opening von Hopfgarten found in the hernial sac a mass of tissue, 4.75 by 3.5 cm., in which there were numerous small subserous cysts, varying in size from a millet seed to a cherry.

His conclusion, after a careful microscopic examination, was that the cysts had their origin in lymph vessels that were dilated from obstruction. He points out the analogy between his case and the lymphangiomas which Wegner claims arise from granulation tissue by secondary changes—in other words, which take their origin from an inflammatory process.

That the lymph channels do proliferate in the ordinary processes incidental to healing seems evident from the descriptions of Talke, who in a recent article has described new lymph vessels in the scar tissue produced as a part of the adhesions about the ascending colon in a case of perityphlitis, and in analogous pleural lesions.

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LYMPHANGIOMA.—See *Angioma* and *Hygroma*.

**LYMPHANGIOMA CIRCUMSCRIPTUM.**—This is an affection characterized by the presence of small vesicles, often arranged in clusters, irregularly distributed, and deeply seated in the skin, and is of rare occurrence. The clusters may have a circular form, or they may be arranged in bands, which sometimes have the appearance of being seated over the course of nerve tracts, or of the large lymphatics. The affection has been found most frequently on the upper extremities, and especially in the scapular and axillary regions, and in a large portion of published cases it has appeared on the left side of the body.

These vesicles vary in size from a pin's head to a small pea, and the epidermis over them is often affected by a warty change, so that some of them may on first sight simulate warts, and occasionally there have been present long warty projections. An interesting feature is the presence usually of telangiectases, or large dilatations of the blood-vessels in the area occupied by the vesicles, as well as in the roof of the vesicles themselves. When the vesicles are ruptured they exude a clear, colorless fluid.

The affection is frequently accompanied by recurrent attacks of an inflammation of the affected area that resembles in type erysipelas, and it has sometimes been classed with the latter disease. These attacks are accompanied usually by some constitutional disturbance and considerable pain. In some instances they have preceded a fresh outbreak of vesicles, in others they have had no perceptible effect on the eruption. They differ from true erysipelas in not spreading to other parts of

the body, and have been compared by Besnier to the "erysipelas" that occurs in elephantiasis.

The affection is very slow in its course, appearing either at birth or in infancy or childhood, and often remaining stationary for many years. There is often an hypertrophy of the fibrous tissue in and about the affected area, so that a condition of elephantiasis may be produced. This is seen also in other varieties of lymph-

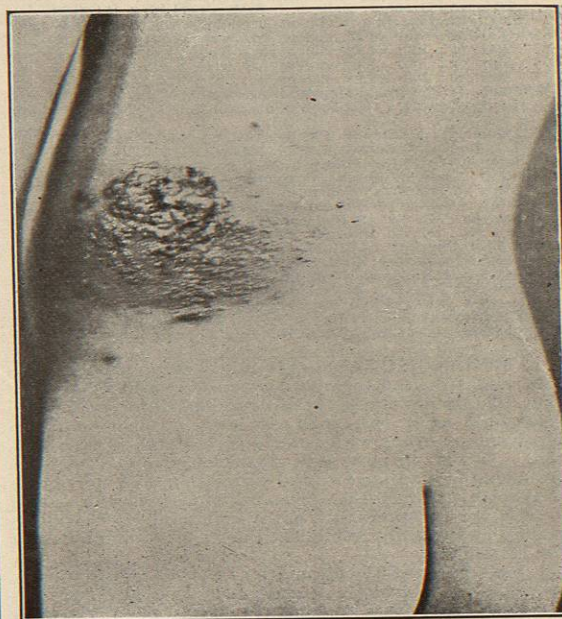


FIG. 3262.—Congenital Lymphangioma Circumscriptum. (Case of Dr. Isadore Dyer, of New Orleans, La.)

angioma. Thick, firmly adherent crusts are often produced by the bursting of the lesions, and, being deeply embedded, they may persist for a long period.

**ETIOLOGY.**—The disease usually begins in infancy or childhood, in one or two cases only in adult life. It is probable that it is always of congenital origin. Injury and irritation have been thought to affect the process, and in several instances excision has led only to an increase in the number of lesions.

**ANATOMY.**—The writer's examination of a lesion removed from the arm, which was not associated with any telangiectases, nor with fibrous or warty changes, showed numerous cysts in the upper part of the corium and approaching very near to the epidermis without implicating it. The cysts were filled with fibrin and a few leucocytes, and were often divided into subdivisions by septa formed of the unaltered corium. These cavities possessed an endothelial lining, and there could be no doubt that they represented newly formed or dilated lymph vessels or channels, as they communicated with the lymph channels below. There was a certain amount of leucocytic infiltration about the cysts. A few enlarged blood-vessels were seen.

The implication of the blood-vessels varies in different cases, and in different lesions in the same case. In some instances it has been found that the corium contains numerous dilated blood-vessels, together with the enlarged lymphatics, and that the telangiectases and vascular dots that have been referred to are caused by the presence of dilated capillary blood-vessels between the upper wall of the cysts and the epidermis.

**DIAGNOSIS.**—This may be made from the appearance

of the affection at birth or in early life, by the groups of thick-walled vesicles, often accompanied by telangiectasis and warty surface changes, by the discharge of lymph, when they are incised, and by the slow course. On superficial inspection the affection may resemble most a group of warts.

**PROGNOSIS.**—The lesions usually increase slowly until they have attained a certain degree of development, when they remain nearly stationary. In one recorded case there has been spontaneous involution. After operative interference, as in all forms of lymphangiomas, the lesions are very likely to reappear.

**TREATMENT.**—Excision and caustics have been tried, but recurrence after the operation is not uncommon. Electrolysis has been thought by some to offer the most hope of success, but in this case also recurrences have been recorded. Each vesicle is to be transfixed by a needle attached to the negative pole of a galvanic battery, eight or ten cells being employed. The poor results of treatment probably are due to the presence of deep-seated anastomoses.

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LYMPHANGIOSARCOMA. See *Sarcoma*.

**LYMPHANGITIS.**—All the tissue elements may be regarded as being bathed in lymph, which appears first in innumerable, minute, irregular gaps in the tissues, which gaps communicate in various ways with each other, and with minute lymphatic vessels, which latter, when traced onward from their beginnings, presently assume a structure comparable to that of narrow veins with very delicate walls and extremely numerous valves. These valves open away from the gaps of the tissues, as the valves of the veins open away from the capillaries. The lymphatic vessels emerging from the network of gaps unite to form somewhat larger ones, which pass either to a neighboring lymphatic gland or to join some larger lymphatic trunk. The lymphatics are arranged into a superficial and a deep set. The superficial lymphatics on the surface of the body are placed immediately beneath the integument, accompanying the superficial veins; they join the deep lymphatics in certain situations by perforating the deep fascia. The deep lymphatics, fewer in number and larger than the superficial, accompany the deep blood-vessels. Finally, the entire system ends in numerous vessels which open into two main trunks of very unequal importance—the thoracic duct and the right lymphatic duct. Lymphatics are found in nearly every texture and every organ of the body which contains blood-vessels. Interposed at numerous points in the course of the lymphatic vessels are the lymphatic nodes, which are small, solid, glandular bodies through which the lymphatic vessels pass. Lymph is the exudate of some of the liquid constituents of the blood as it circulates through the capillary blood-vessels into the tissue gaps or spaces, and carries nutriment to the tissues. It then receives from the tissues the products of their activity, and is collected from the lymph spaces into their lymph channels, whence it is carried to the lymph nodes, which act as filters for the lymph, besides adding to the lymph the lymphocytes, which act as scavengers (phagocytes) in the lymph and blood.

Reticular lymphangitis is applied to inflammation of circumscribed areas of lymphatic radicles, tubular lymphangitis to that of the larger continuous lymphatic trunks. Both forms often coexist. Either may be acute or chronic. Since we now know that all inflammation of lymph vessels is of microbic origin, we may drop the terms "idiopathic" and "traumatic" as being no longer descriptive. The lymphatics are so widely distributed that they must be severed or torn in every cut or bruise to a greater or less extent; but, as a rule, they collapse at once and give no trouble. From their open mouths, during the first hours following the receipt of a wound, comes much of the serous flow, to dispose of which drainage is necessary. This outward flow of the lymph, together with its coagulation and the collapse of the lymph vessels themselves, prevents the absorption into the or-

ganism, in most instances, of septic material. While lymphangitis is, generally speaking, the consequence of a wound, yet this is not an invariable rule, since infection has been known to penetrate through the unbroken skin of the hand, as seen in sepsis following immersion of the unwounded hands in the fluids of a cadaver at an autopsy, and also through mucous membranes in which there is no abrasion or scratch to be found, especially in the case of the throat, uterus, etc. The absorption of infective material is undoubtedly greatly facilitated by friction, pressure, the removal of the outer corneous layer, or the confining of a discharge under tension. Recent wounds are much more likely to be attacked than granulating ones, because granulations themselves, so long as they are uninjured, do not absorb, the current setting in the opposite direction toward the surface. Whatever the irritant may be, it probably does not cause inflammation of the wall of the vessel unless it is arrested; if this does not take place, it is hurried on to the neighboring lymphatic glands, and sets up inflammation there. Illustration of this is seen in cases in which surgeons have received the tiniest needle prick, so slight as to leave no mark, in which the first intimation of sepsis is found in inflamed lymph nodes in the neighborhood. The heat of the sun and the Roentgen rays produce an inflammation of the skin in which the lymphatics share to a certain extent. Lymphangitis is incidental to the course of specific diseases, such as scarlet fever, measles, diphtheria, tuberculosis, syphilis, and gonorrhœa; in these, however, the inflammation of the lymphatic nodes is the more prominent feature. A typical lymphangitis is seen in erysipelas (which see). It may also result from the bites of insects and venomous reptiles. It is a constant lesion in bubonic plague.

**PATHOLOGY.**—The changes are best seen in the larger trunks. Their endothelial cells swell, lose their distinctness of outline, and to a variable extent become detached. The walls of the lymph vessels and the delicate surrounding cellular tissue become more or less densely infiltrated with pus cells, fibrin, and serum. The lumen of the vessel, the interstices in its walls, and the cellular sheath are filled with a coagulating exudate. The stream of lymph through the vessel ceases because of the thrombus. The blood-vessels surrounding the inflamed area dilate, and the blood circulates more rapidly and in greater quantity. The future course, whether it is to be either resolution, organization, or suppuration, depends upon the cause. If the irritant be slight and transient, resolution may begin at once. The thrombus liquefies within the lumen, and the exudate within and without the walls is absorbed. The endothelium is regenerated and the circulation is re-established. Organization is likely to occur if the irritant action is chronic and persistent, as in syphilis. The lumen becomes occluded through transformation of the thrombus into connective tissue, and the coats of the vessels and the cellular tissues in which they lie become hard, dense, and sclerosed, likewise from organization of the exudate into connective tissue, and some degree of permanent thickening results in the tissues. Suppuration takes place when virulent micro-organisms are the exciting cause, producing coagulation-necrosis of the thrombus and exudate, and death of the vessel wall and surrounding tissues, resulting in cellulitis, or abscess, which may be circumscribed, or diffuse and spreading. The related neighboring lymph nodes are usually implicated also. The results of the extension of infection along the lymphatic channels are seen in some cases of suppurative appendicitis, where we may find inflamed mesenteric glands, isolated abscesses about the liver, empyema, etc.

**SYMPTOMS.**—In the reticular form the inflammation shows itself in red, tender, oedematous, swollen patches, which may succeed each other up the limb, one fading as a neighboring area blooms out. The inflammation extends from the periphery. Pain is always present and varies, like the other symptoms, with the severity and extent of the process; it is increased by movement, and is accompanied by a feeling of tension in the part. Ordinary erysipelas presents a typical form of reticular