The Management of Chylothorax *

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A REVIEW of the cases of chylothorax treated by the Chest Service at Barnes Hospital revealed some interesting facts that are not emphasized in the literature and, that, we believe, are important in the management of these cases. The numerous papers on the subject deal too much with technical triumphs under unique circumstances. There is little that is correlative or helpful.

Embryology and Anatomy

The lymphatic vessels in mammals arise by the budding of primary lymph sacs from the veins in four areas. A paired jugular set of sacs arise from the anterior cardinal veins. A paired iliac set of sacs, a retroperitoneal lymph sac, and cisterna chyli are formed by budding from the mesonephric vein and the veins in the dorsomedial edge of the wolffian bodies. The thoracic duct system is formed by the union of a duct or ducts growing caudad from the jugular sacs and a plexus arising from the cisterna chyli and extending cephalad. Endothelial sprouting centrifugally from these primitive sacs occurs to complete the lymphatic network.[35, 36]

The lymphatic drainage into the venous system in the left cervical region is made up of ducts from three regions: the left deep cervical duct draining the left side of the head and neck, the left subclavian duct draining the left forequarter, and the thoracic duct draining the abdominal viscera and the lower extremities. On the right side, the deep cervical duct and subclavian duct drain comparable portions of the head, neck, and upper extremity. The bronchomediastinal branch drains the right side of the thorax, right lung, pleura, lower portion of left lung, pericardium, heart, a portion of the convex surface of the liver, both diaphragms, and the peritoneum.

The thoracic duct typically begins at the upper border of the cisterna or receptaculum chyli at the level of the 2nd lumbar vertebra (Fig. 1). A single duct passes through the aortic hiatus of the diaphragm between the azygos vein and aorta, slightly to the right side of the vertebral column. At the level of the 4th or 6th dorsal vertebra, the duct crosses to the left of the vertebral column and continues cephalad to enter the superior mediastinum between the aortic arch and left subclavian artery and the left side of the esophagus. After passing the thoracic inlet, the duct arches 3 to 5 cm. above the clavicle and passes anterior to the subclavian artery, vertebral artery, and thyrocervical trunk to terminate in the region of the angle formed by the junction of the left jugular and subclavian veins.

Wide anatomic variations may exist in all portions of the duct (Fig. 2). The cisterna chyli may vary in position and on occasion has been found absent. Dual ducts with multiple anastomotic channels, as the duct passes through the diaphragm and mediastinum, are recorded,[12, 26] although one study showed the duct to be single in

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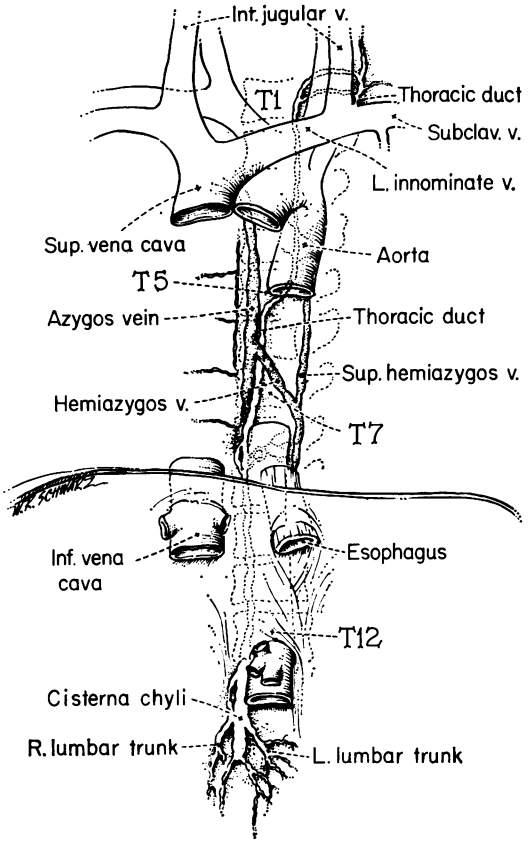

FIG. 1. Anatomic Relationship of the Thoracic Duct. (Reprinted with the permission of the Editor and Publisher of the Journal of Trauma.)

all instances below the 8th dorsal vertebra.[43] In addition to multiple anastomoses between lymphatic channels, there may be direct lymphatico-venous communication with the azygos vein. The duct may continue on the right side of the vertebral column to enter into the veins in the right subclavian region. Termination of the duct on right or left may be into jugular subclavian, innominate or vertebral veins and may vary from one channel to a delta-like arrangement with two or more channels entering the venous system.[46] These anatomic variations complicate the surgical approach to closure of the duct, and may completely frustrate such efforts.

Physiology

The formation and flow of lymph and chyle are dependent upon factors which vary with each organ system and with the particular state of activity of the system at the time. Numerous experiments in laboratory animals and more limited experiences with patients have amply demonstrated the principles of lymph formation and flow. Understanding these principles and applying measures designed insofar as possible to control formation and flow will be of benefit in the care of patients with chylothorax.

The loss of lymph from the right lymphatic duct or any of its three principal tributaries will not, in the absence of either functioning anastomoses or anomalous thoracic duct drainage, cause a loss of chyle. The right lymphatic duct drains a considerable portion of the body, including the greater portion of lymph formed from lungs, heart, pleura, pericardium, diaphragm, peritoneum, right upper extremity and right side of the head and neck. The lymph within the right lymphatic duct does not contain, therefore, the high fat content contributed to the thoracic duct by the digestive system. The thoracic duct conducts the lymph and chyle from the intestinal and hepatic lymphatics and from both lower extremities.

The formation of lymph from the alimentary tract occurs largely from the small intestine where during digestion considerable volumes of fluid, extravascular protein, and fat pass into the lymphatics. The increased flow during digestion is largely from the absorbed water and fat, as protein and carbohydrate ingestion have been found to cause little or no increase in lymph flow. The absorption of fat may increase lymph flow two to ten times the resting level for several hours.[10, 22] The lymphatics of the esophagus, stomach, and large intestine are concerned mainly with the removal of extravascular protein.

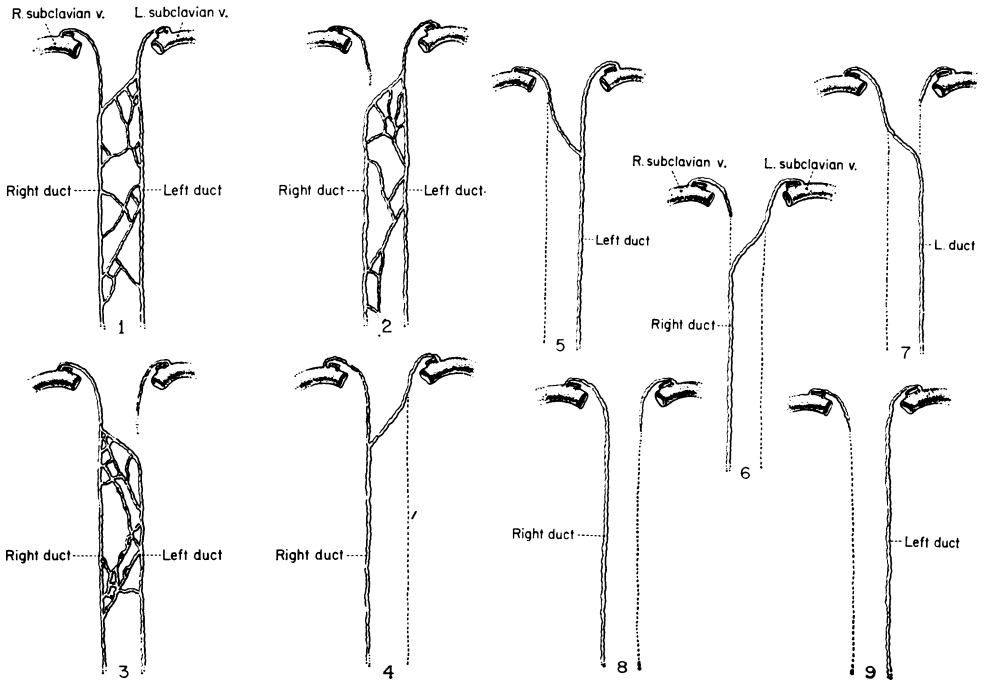

FIG. 2. Schematic Representation of Variations of Thoracic Duct. Redrawn from Davis, H. K.[12] (Reprinted with the permisison of the Editor and Publisher of the Journal of Trauma.)

Hepatic lymph has been shown by direct measurement to contribute ¼ to ½ of the total volume of lymph flow in the thoracic duct.[9, 30] This lymph has a high protein concentration, approximating very closely the amount of protein found in circulating plasma. A high proportion of the protein found in thoracic duct lymph comes from hepatic lymph.

Lymph flow from the lower extremities is negligible in the absence of motion or inflammation.

The movement of lymph within the lymphatic vessel is brought about by forces extrinsic to the lymphatics. An increase in tissue pressure, as by active or passive movement or massage, will cause a rise in lymph pressure within the vessel with consequent lymph flow centripetally to a region of lower intralymphatic pressure. Numerous valves within the lymphatics prevent regurgitant flow. Direct pressure upon the cisterna chyli, as caused by increased intra-abdominal pressure associated with coughing, straining, or lifting, will effect a propulsion of lymph along the thoracic duct.

Respiration is particularly important in lymph flow. In addition to its direct effect from continuous, rhythmic, muscular action, breathing affects the venous pressure against which the thoracic and right lymphatic ducts empty their contents. Rouviere *et al.*[34] found flow from the thoracic duct to be into the vein during inspiration only.

Such drugs as Pitressin, pilocarpine, and acetylcholine, by their effect upon peristalsis in anesthetized animals, have been shown to augment thoracic duct flow.[3, 44] Histamine and related drugs causing increased capillary permeability will effect an increase in lymph flow. Increase in local body temperature will also bring about increased lymph flow when the temperature remains within physiological limits.

TABLE 1. *Etiology*

A. Obstruction	
1. Intrinsic	
a. Neoplasm	
b. Developmental abnormality	
c. Filariasis	
2. Extrinsic	
a. Neoplasm	
b. Infection	
c. Subclavian vein occlusion	
d. Aortic aneurysm	
B. Trauma	
1. Blunt trauma	
2. Penetrating wounds	
3. Surgical procedures	
4. Abnormal stress	
a. Coughing	
b. Hyperextension of spine	
c. Weight lifting	
5. Diagnostic procedures	
a. Aortography	
b. Left heart catheterization	
C. Idiopathic	

Physical Characteristics

The basic constituents of lymph and chyle resemble very closely those of plasma. Electrophoretic studies of the protein fractions of lymph show all proteins found in plasma to be present in lymph although in different proportions relative to the molecular size of the protein. Cholesterol and phospholipid are largely associated with the protein fraction as lipoprotein. The ionic pattern resembles very closely that of plasma as does that of the readily diffusible nonprotein constituents such as glucose, amino acids, urea, and creatinine. Enzymes including cholinesterase, diastase, and alkaline phosphatase are found. Neutral fat in the form of chylomicrons is present dependent upon the degree of fat absorption from the intestine.

Chyle appears grossly as an opalescent milky fluid which separates upon standing into three layers: a creamy layer uppermost, a milky intermediate layer, and a dependent layer containing cellular elements. The principal cell found in chyle is the lymphocyte.

Chyle has been found to be bacteriostatic and able to tolerate room temperatures for weeks without putrefaction. Lampson [24] reported studies which showed that Escherichia coli and Staphylococcus aureus 204 were unable to grow in 100 per cent chyle, although they were able to grow in media with lesser concentration of chyle. Transplants from pure chyle to blood agar plates showed four plus growth indicating that pure chyle is bacteriostatic and not bactericidal.

Chyle which is extravasated within the pleural cavity is relatively nonirritating to the pleura and does not evoke the formation of a peel or fibroblastic membrane.

Etiology

Table 1 summarizes etiology under three headings. In patients with obstruction of the duct, it is quite likely that slight degrees of trauma may produce laceration of an attenuated duct fixed in place by neoplastic or inflammatory tissue. It is also quite difficult to be certain that trauma is not important in the group of cases classed as idiopathic, as most of the cases are in infants in whom trauma could pass undetected.

The intrinsic lesions involving the thoracic duct are of unusual occurrence.[41] Of the obstructing lesions, malignant neoplasms are most frequently encountered. Blockage by infectious processes,[5] aneurysms,[45] or obstruction within the subclavian vein [33] are infrequently associated with chylothorax.

Traumatic disruption of the duct is encountered in a wide variety of causes. In addition to blunt trauma, penetrating wounds, and surgical procedures,[10, 21, 38] abnormal stress or exercise including coughing, back diving, and weight lifting have been recorded.[21, 24, 32, 41] Accidental injury to the duct has been incurred during aortography and left heart catheterization.[16, 31]

Idiopathic or spontaneous cases are

recognized most frequently in infants in whom the exclusion of birth or neonatal injury is difficult.[7, 14] A small number of postmortem examinations in infants with chylothorax have shown hypoplasia of the thoracic duct. An occasional case in infants has been reported where postmortem examination failed to demonstrate any trace of a duct system.

Clinical Material

In our group of 11 cases, five were due to trauma and six were not.

Of the five cases due to trauma, one was penetrating (gunshot wound), two were surgical (operative), and two were associated with crushing injuries of the chest. Of this group, three lived and two died. One patient expired with persistent chylothorax following an operation for unresectable carcinoma of the esophagus. The remaining death in this group was in a patient with multiple extensive fractures and injuries in whom the chylothorax was only a partially contributing cause. The chylothorax did not reaccumulate following a solitary thoracentesis in one patient. The remaining two patients were treated with nonoperative measures and were free of reaccumulation after 12 and 19 days of treatment, respectively. In no patient in this group was it necessary to operate for control of the chylothorax.

Of the remaining six cases, two occurred in infants. One infant treated in 1943 expired despite intensive conservative treatment. At postmortem examination no cisterna chyli or thoracic duct could be located. The remaining infant was operated upon after two weeks of unsuccessful conservative therapy. The duct could not be identified at operation, but multiple sutures in the supradiaphragmatic region of the duct succeeded in permanently arresting chyle loss.

Three of the remaining four cases suspected of having mediastinal malignancy were proven to have malignant tumors, while the 4th declined definitive diagnostic procedures.

One patient with reticulum cell sarcoma was treated with x-ray therapy and was not troubled with chyle accumulation following this therapy. The diagnosis of reticulum cell sarcoma in another patient was made only at autopsy despite an illness of five years duration during which time multiple diagnostic and therapeutic procedures were undertaken. In this case chylothorax appeared initially on the right side and was partially controlled with multiple thoracenteses and an intercostal catheter. The chyle then appeared on the left side, and a thoracotomy with double ligation of the thoracic duct was done. Chyle loss stopped temporarily but recurred two months later requiring further conservative measures. The last patient had an undifferentiated carcinoma in the neck and superior mediastinum. Chyle loss first appeared in this patient following operative removal of the tumor in the neck and mediastinum. Conservative measures failed to control this loss, and a right thoracotomy with ductal ligation and parietal pleurectomy was done. Within two months chylothorax appeared on the left. This was treated conservatively, and no further fluid reaccumulated after one month.

Thus in the total group, none of the five cases due to trauma was treated by operative intervention. One of the two infants was operated upon as were two of the four cases caused by malignancy.

In both of the latter cases, operation was performed without the establishment of the diagnosis either before or at the time of operation. In both cases the actual point or points of rupture were not demonstrated, but double proximal ligation was carried out. In both cases recurrence of chyle accumulation supervened, and the institution of other methods to control chyle loss was necessary.

Of the total group, three cases were operated upon with ligation of the thoracic duct, and two of the three required supplemental therapy.

Discussion

The diagnosis of chylothorax in the average patient presents no problem. The x-ray shows a typically unencapsulated pleural effusion which when removed appears creamy and opalescent and separates upon standing into three layers. A smear of the fluid shows predominantly lymphocytes, and culture is sterile.

There have been many diagnostic tests suggested which would relate the pleural fluid more exactly as being of lymph or chyle derivation. A coal tar dye labelled Drug & Cosmetic Green No. 6, when ingested with a high fat meal, will impart a green color to chyle which is easily distinguishable from normal body fluids. The green color has the particular advantage which many lipophilic dyes lack, that of being readily distinguishable from blood.[23] Increased flow in the thoracic duct is perhaps most readily and reproducibly achieved with subcutaneous administration of 1 per cent aqueous solution of Evans Blue (T-1824) in doses of 0.7 to 0.8 mg./kg. into the thigh region.[29]

When a significant loss of chyle is present, utilization of certain measures will help minimize this loss. Measurements in man show average lymph flow from the thoracic duct to be 2 ml./kg./hr. When lymph is collected from animals at rest or under general anesthesia, there is no appreciable flow in the thoracic duct from the limbs or from any organ other than the liver or gastrointestinal tract. The thoracic viscera, from which a constant basal flow is expected, drain most of their lymph into the right lymphatic duct. In the absence of inflammation of the lower extremities, which augments lymph flow, the restriction of active or passive motion and massage will allow only a negligible amount of lymph flow. Drugs used to increase vasodilatation, heat applications, or subcutaneous fluids into the lower extremities should not be permitted.

The contribution of chyle from the digestive tract is largely through the absorption of water and/or fat, while the absorption of carbohydrates and protein contributes little. The restriction of all food or fluid by mouth will lessen considerably the amount of chyle formed. All drugs which augment intestinal peristalsis should be avoided.

Actions which increase intra-abdominal pressure such as coughing, laughing, straining, and massage should be minimized. Respiration should be encouraged to remain at basal rates. Sedatives and antitussive medications may be beneficial toward these ends. Slight elevation of the head of the bed will aid in decreasing chyle flow within the duct.

Surgical ligation of the thoracic duct at any point along its course is well tolerated. Lee found that, following ligation of the thoracic duct in cats, two types of collateral circulation were developed. Firstly, a collateral draining was established with the right lymphatic duct. Secondly, lymphaticovenous connections were found to exist between the thoracic duct and azygos vein. Following ligation the cisterna chyli was never found to be ruptured, although edema developed about the large lymphatics and cisterna chyli. This edema was well established by 24 hours and persisted for one week.[25] Blalock's studies also showed this enlargement of accessory ducts and anastomotic channels.[4] Numerous clinical examples have now further proved the feasibility of ligation of the thoracic duct at any point in its course.

Before 1946, surgical ligation of the duct within the mediastinum was discussed only to point out its futility, despite the known fact for many years that it was anatomically

and physiologically practical. Lampson, in 1946, performed the first successful transpleural mediastinal ligation of a thoracic duct severance of vague etiology, possibly severe coughing.[24] Ligation of the duct within the neck has long been discussed and known to be practical. Cushing reported two such cases of thoracic duct injury, both of which occurred during the performance of the supraclavicular dissection utilized at that time in the Halstead operation for carcinoma of the breast.[11] Deanesly in 1903 implanted the divided duct into the jugular vein which had been ligated because of its injury during the operation.[13] Harrison described a case of surgical division of the duct which he treated by implantation of the divided duct into the divided end of the external jugular vein.[19]

The thoracic duct within the posterior mediastinum continued for a time to be considered surgically inaccessible, and adequate surgical approach to lesions of the duct which presented into the mediastinum or thorax was lacking. Several indirect methods of approach were suggested during this period. Van Nuys, in 1931, utilized deep x-ray therapy to the lower mediastinum in a patient with chylothorax and chylous ascites of undetermined etiology and concluded that this therapy had benefited his patient.[42] In 1937, Brown suggested an extrapleural, extraperitoneal, paravertebral approach on the right side for external drainage of extravasated chyle.[8] Nowak and Barton carried out phrenicectomy for relief of a persistently reaccumulating chylothorax which proved at autopsy to be from a rent in the thoracic duct at the level of T 8. The rationale of the procedure as suggested by these authors was the attendant elongation and narrowing of the crural sulcus together with limitation of respiratory movements.[32] Intrapleural medicaments including 1 per cent gomenol in mineral oil, 1:3,000 saline solution of azochloramid and sterile broth have been reported by various authors.[2, 18, 28, 39] Therapeutic pneumoperitoneum was used by Florer & Oschmer as an adjunct to phrenicotomy.[15]

In addition to double ligation of the duct at the defect and ligature of the duct just cephalad to the diaphragm, other operative procedures have been suggested. Implantation of the severed duct into a vein, such as the azygos, has been successfully accomplished.[20] Seaman utilized a *pleural cone* to occlude the traumatic opening into the thoracic duct and thereby preserved the integrity of the duct.[37] The development of effective collateral lymphatic channels and direct lymphatico-venous connections which have been demonstrated in experimental animals, and the complete absence of untoward sequelae from ligation of the thoracic duct in patients would seem to render unnecessary those procedures which are directed toward maintaining the continuity of the primary thoracic duct or reimplanting the thoracic duct into the venous system. Ligation within the mediastinum has now been utilized by surgeons and is believed by most to be the favored procedure when an operative approach is indicated.

Individuals presenting with a chylothorax following trauma to the thoracic duct require removal of the fluid as completely as possible and as frequently as necessary. Either repeated thoracenteses or an intercostal catheter connected to a water-seal bottle may be used. We prefer water-seal drainage. It is particularly in this group of patients that measures directed toward minimizing chyle formation and favoring early closure of the duct are most applicable and rewarding. An acute injury to the duct may be expected to heal quite readily if fluid loss through this leak is minimized and dead space is obliterated by constant removal of the chyle. Lymph flow from the extremities should be minimized by allowing only an absolute mini-

mum of physical activity. Food and fluid administration should be withheld by mouth and nasogastric suction instituted. Parenteral fluid administration should be by the intravenous rather than subcutaneous route so that lymphatic flow from subcutaneous fluids is not produced. Positioning of the patient with the head of the bed slightly elevated should be utilized, and all practical efforts should be made to diminish such activities as coughing, straining and laughing. If such measures are unsuccessful in showing improvement after two weeks, and we believe these cases will be extremely rare, an exploratory thoracotomy upon the side presenting the chylothorax is necessary. In the event the leakage from the duct or the duct itself cannot be identified, pleurectomy and poudrage may help obliterate the fistula.

Chylothorax when associated with obstruction, which is usually malignant, to the thoracic duct is likely not to respond to simple conservative methods. In addition to a poor response to simple conservative measures, this type of mediastinal involvement makes any surgical approach for correction of a leak impractical. Treatment with radiation of a radiosensitive malignancy in this region will often be rewarded by cessation of chyle loss. If the malignancy is not radiation or drug sensitive and the patient's general condition and life expectancy seem to warrant them, thoracotomy with ductal ligation, pleurectomy, or poudrage, or other expedients such as intrapleural nitrogen mustard may be utilized to prolong comfort and useful existence. Proof of the exact etiology is occasionally difficult to achieve even though thoracotomy has been performed for the purpose of diagnosis and ductal ligation.

Chylothorax, which is secondary to any form of trauma, is more likely to respond favorably to nonoperative measures than is chylothorax from other causes. This may well be expected as the healing of a single disruption in duct continuity would seem more likely to occur than would cessation of extravasation from a duct which has multiple points of obstruction. A favorable outcome may usually be anticipated in traumatic cases and justifies a period of trial of non-operative measures reserving the surgical approach only for the cases that do not respond.

Our experience strongly suggests that the surgical approach as the primary method of treatment in chylothorax is rarely indicated. In traumatic cases, we believe it will rarely be necessary, and in malignant types it will never be effective.

Summary

1. Eleven cases of chylothorax of diverse etiology treated by the Chest Service at Barnes Hospital during the years 1940 to 1959 are presented.

2. A brief discussion of the anatomy and physiology of the thoracic duct and its chyle flow is presented, and an attempt is made to correlate basic principles with management of patients having chylothorax.

3. An outline of therapy is presented stressing that therapy must be chosen and modified with consideration for the cause and clinical response of each case.

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