eISSN 1308-4038

International Journal of Anatomical Variations (2013) 6: 221–224

Case Report

A previously undocumented pre-aortic pathway of the thoracic duct: a case report

Published online December 28th, 2013 © http://www.ijav.org

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Received March 7th, 2013; accepted August 28th, 2013

Abstract

A 59-year-old female presented with a pre-aortic thoracic duct during gross anatomical dissection at Ross University School of Medicine. Anatomical knowledge of the pathway and variations of this duct are clinically important in order to avoid severing the structure during surgery and the consequent chylous leakage, which may be terminal. Many unusual thoracic duct pathways have been documented in the literature, including variations in the origin and course of the structure, as well as in the way the duct terminates into the venous system. However, there are no reported variations of the duct passing anterior to the descending thoracic aorta as described within this case report. Recognition of this variation is important for clinicians performing thoracic surgeries, especially certain procedures that would not normally have involved concerns regarding the ligation of the thoracic duct.

Key words [thoracic duct] [chyle] [lymphatic system] [thoracic surgery] [pre-aortic]

Introduction

The lymphatic system is composed of a vascular network of blind-ended capillaries and larger vessels that drain lymph from the organs into major collecting ducts. The majority of these major collecting ducts subsequently drain into the thoracic duct and, through the thoracic duct, into the venous system [1]. Literature regarding the lymphatic system and its components has been remarkably limited since the identification of the thoracic duct in 1961 and the full description of the lymphatic system completed in 1965 [2]. The recent discovery that metastatic tumor cells are distributed throughout the body by the lymphatic system has renewed interest in the development and variations of the lymphatic system, as well as its contribution to health and disease. The embryological development of the system, however, is still not thoroughly understood.

The preponderance of previous interest in the lymphatic system was towards variations in the course of the thoracic duct, due to the complications of ligating or damaging this structure. This has resulted in extensive documentation of the duct pathway variations compared with the sparse literature regarding the rest of the system. The thoracic duct is the major lymphatic channel, collecting lymph from the entire body with the exception of the right superior quadrant (right half of the thorax, right upper limb and right side of the head and neck). Anatomical knowledge of the course of the duct and its tributaries, as well as possible variations is essential clinically, to avoid damage to this structure and the resulting leakage of chyle, which may be a life threatening condition [3, 4]. The literature documents the typical origin, course [5, 6] and termination of the duct into the venous system, as well as several atypical pathways, making the thoracic duct the most extensively documented component of the lymphatic system [7]. The atypical presentations documented to-date do not include passage of the thoracic duct anterior to the thoracic aorta, as reported in this case. Recognition of this unique pathway for the duct is important for clinicians performing surgeries, especially in procedures that would not normally require considerations of a possible thoracic duct ligation.

The embryological development of the lymphatic system receives very brief attention in embryology texts, resulting in a very superficial description of the timing and process of its development. This is because the origin of the lymphatic channels is poorly understood and literature is divided over how and where these channels originate [8]. One view is that they have origins from venous endothelium while another suggests an origin from local mesoderm; however, there is no current consensus on the embryological origin of lymphatic channels [8]. Regardless of the disagreement of the origin, both viewpoints concur that the lymphatic system

first appears as six primary lymph sacs towards the end of the sixth week in utero. During the eighth week in utero, two jugular lymph sacs appear at the angle between the future internal jugular and subclavian veins, while a retroperitoneal lymph sac forms in the abdomen on the posterior abdominal wall posterior to the root of the mesentery. The cisterna chyli forms later at the same level as the retroperitoneal lymph sac, but it is positioned posterior to the aorta [8]. At the same time, a pair of posterior lymph sacs arises at the bifurcation of the femoral and sciatic veins. By the end of the ninth week in utero, lymphatic vessels connect the lymphatic sacs to each other, while additional lymphatic vessels connect the cysterna chyli to the jugular sacs. An anastomosis then develops between these two channels resulting in a single lymphatic vessel which is formed by the caudal part of the right channel, the anastomotic segment in the middle and the cranial part of the left channel superiorly, which will eventually form the thoracic duct. Due to the nature of the lymphatic vessel anastomoses, which ultimately form the duct, congenital variations may occur both within the course and formation of the duct [8].

The pathway of the thoracic duct can be classified as either "typical or "atypical", where the "typical" pathway is more common [5]. The typical pathway will be described first, followed by a description of documented atypical patterns. In the "normal" pathway, the thoracic duct begins anterior to the first and second lumbar vertebrae, where two lumbar lymphatic trunks and a single intestinal lymphatic trunk join together to form the thoracic duct [5, 7]. At this junction, there may also be a bulging of the duct, the cisterna chyli, which is a reservoir for collecting lymph present in 25-47% of individuals [3]. The thoracic duct then ascends from the cisterna chyli, passing posterior to the median arcuate ligament of the diaphragm. It ascends through the diaphragm, along with the aorta and the azygos vein, before passing superiorly through the right posterior mediastinum between the thoracic aorta on the left side and the azygos vein on the right side [6, 9]. At approximately the level of the intervertebral disc between the fourth and fifth thoracic vertebrae, the thoracic duct crosses over the midline into the left posterior mediastinum, where it ascends through the thoracic inlet on the left side of the esophagus, while coursing posterior to the aortic arch. The thoracic duct arches 3-4 cm above the clavicle in the cervical region, passing anterior to the vertebral artery and vein, left sympathetic trunk, thyrocervical trunk, left phrenic nerve and medial border of the anterior scalene muscle [9]. During its passage in the cervical region, the duct also passes posterior to the left common carotid artery, the left vagus nerve and the left internal jugular vein before terminating as it drains into the junction between the left subclavian and left internal jugular veins, also known as the venous angle [8].

The unusual thoracic duct

Chyle is transported by the thoracic duct back into the venous system. In addition to the duct, chyle may also be found in the mesenteric lymphatic ducts and cysterna chyli of healthy individuals. Chyle present in any other body cavity suggests a leakage of chyle from the lymphatic system [5, 10], which may be a terminal condition. Chyle leakage from this system may be the result of disruption of the thoracic duct due in a number of possible instances including diseases, penetrating traumas, degeneration of the duct itself and lymphatic disorders. These will consequently result in either a chylothorax or chyloperitoneum depending on the location of the leak. Research has shown that the thoracic duct is damaged in 0.37-2% of central venous catheter placements, and in 4% of esophageal resections [10]. Chylous leakage from the thoracic duct occurs at a rate of 60-190 milliliters per hour [6, 8] and is life threatening in 0.9-4.7% of cases [4]. Additional scenarios, which may cause the rupturing of the thoracic duct, include the hyperextension of the vertebral column and fracture/dislocation of the spine [10]. There is, no current literature documenting whether or not the number of accidental ligations is correlated directly to the presence of variations. In a surgery where the duct has an anomalous pathway however, it does increase the possibility of disruption.

Due to the complex nature by which the thoracic duct develops, congenital variations in the thoracic duct and its pathway are expected to be present by the second month of embryonic development and should be equally frequent in both sexes [7]. These congenital variations of the duct, however, are extremely rare, as shown by Cha et al. (1976) in their review of the thoracic duct and its variations [6]. The authors identified the pathway of the thoracic duct in 243 cases and found 65 contained variations that could be separated into classifications of variations depending upon the extent of their deviation from the expected pathway (Table 1) [4]. In addition, the authors conclude that the origin of the duct from multiple channels rather than a single duct from the cysterna chyli is more frequent than described in earlier research. They propose this is a result of incorrect positioning of the patient during visualization prior to surgical procedures, which affects the accuracy of the visualization procedure itself. The authors also suggest that the recent decrease in the use of lymphangiography to visualize the thoracic duct has been detrimental to the prevention of damage to the thoracic duct because the current techniques of MRI and CT scanning do not accurately map the duct's course, resulting in unnecessary risks of ligation. Consequently, Cha et al. (1976) suggest the reintroduction of lymphangiography prior to surgery to map the duct's pathway in order to further reduce the number of ligations [4].

Case Report

This case of a pre-aortic thoracic duct was identified in a 59-year-old female during gross anatomical dissection at Ross University School of Medicine. The cause of death of this individual was respiratory failure. Through the initial part of its course, the thoracic duct is normally located within and ascended through the aortic hiatus, posterior to the median arcuate ligament of the diaphragm. Once the duct has ascended through the hiatus, it was located parallel to the aorta on the right hand side of the posterior mediastinum (Figure 1). At the approximate level of the tenth thoracic vertebra, the duct crossed the midline from right to left, anterior to the

Table 1. Classification of Thoracic Duct Variations in 65 cases of thoracic duct variation, modified from the source [2].

Type		Description	% of Cases
1		**A single thoracic duct emptying into right vein**	3
2		**Duplication of the thoracic duct**	29
	a	Complete duplication of thoracic duct	9
	b	Incomplete duplication	20
	bi	Y-shaped thoracic duct	11
	bii	Inverted Y-shaped thoracic duct	9
3		**Segmented plexus formation**	51
	a	Upper third	14
	b	Middle third	20
	c	Lower third	17
4		**Multiple plexus formation**	17
	a	With main duct	9
	b	Without a main duct	8

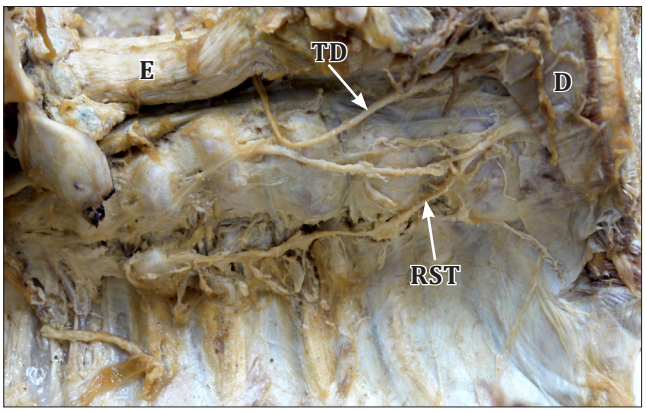

Figure 1. Figure shows the pathway of the *thoracic duct (**TD**) on the right hand side of the thoracic cavity in the posterior media*stinum. The superior mediastinum is on the left hand side of the figure and the abdomen is on the right side. *(**D**: diaphragm; **E**: esophagus; **RST**: right sympathetic trunk)*

azygos vein and descending thoracic aorta but posterior to the esophagus (Figure 2). Once the duct reached the level of approximately the sixth and seventh thoracic vertebrae, it moved posterior to the descending thoracic aorta and was once more within the expected location: posterior to the aortic arch. The duct then terminated as expected, as a single duct draining into the junction between the left internal jugular vein and the left subclavian vein. The duct does not fit into the categories established by Cha et al. (1976) because the duct itself is not variant; it is the pathway of the duct

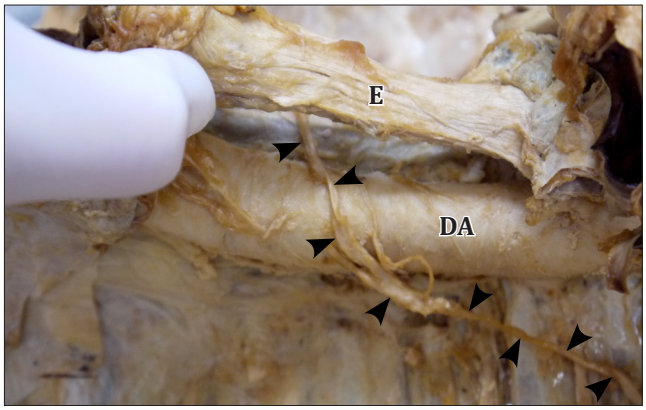

Figure 2. Figure shows the *thoracic duct (**outlined in black arrowheads**)* in the left side of the thorax, coursing anterior to the *descending aorta (**DA**)* and posterior to the *esophagus (**E**)* at approximately the tenth thoracic vertebrae level. In this image, the abdomen is to the left side of the figure and the superior mediastinum is to the right side.

passing anterior to the descending aorta and posterior to the esophagus that is the variation in this instance.

Discussion

Our knowledge of the lymphatic system has increased due to the understanding that metastatic cancer cells may spread through the lymphatic system. The anatomy of the thoracic duct continues to be a focus within the study of the lymphatic system, because of the risks involved with damage to this vital structure. Injury to the thoracic duct can substantially increase the morbidity of a patient after a relatively standard thoracic surgery, and may even prove fatal. Thus, the course and pathway of the duct must be carefully documented, and efforts must be made to raise the awareness of the presence of congenital variations amongst clinicians.

While rare, atypical thoracic duct pathways potentially increase the occurrence of damage to this structure. Rates of injury to the thoracic duct during surgery are not high, but simple steps, including the reintroduction of lymphangiography to delineate the lymphatic pathways prior to surgery and the correct positioning of the patient during imaging, may improve the mapping of the duct. Such steps may substantially reduce the occurrences of damage; both in normal and particularly in abnormal cases, such as the unique pathway documented in this case study.

Conclusion

In conclusion, injury and the subsequent chylous leakage from the thoracic duct is a rare post-operative diagnosis. Densupsoontorn et al. (2005) completed a retrospective study at a pediatric hospital following 1683 cardiothoracic procedures reporting the incidence of post-operative chylothorax and chyloperitoneum of 0.89% and 0.12%, respectively [11]. In these cases, the authors found that it was not the duct which was ligated directly, but tributaries to the

duct. Therefore, it can be argued that the variations are not to be considered the only reason for the duct ligation to occur. In addition, it should be emphasized that many of the previously described variations (Table 1) are extremely common with the segmental plexus formation present in 51% of the variations in that particular instance, for example. Therefore, while the variations are considered to be rare, the frequency of certain variations is considerably higher than others and should be expected by the imaging technicians mapping the pathways prior to cardiothoracic surgeries.

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