The cisterna chyli and thoracic duct in pigs (*Sus scrofa domestica*)

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ABSTRACT: Anatomical variations of the thoracic duct course are common in humans and domestic animals. They are important in thoracic surgery and in application of surgical techniques in experimental animals. The pig is a frequently used animal model due to numerous similarities between human and porcine anatomy and physiology. We revealed the position of the cisterna chyli, and the origin, course and termination of the thoracic duct by fine dissection on fifteen Yorkshire pig carcasses. The pigs were 2.5 months old with a body mass range from 10 to 15 kg. In this study we present our macroscopic observations. The cisterna chyli and thoracic duct had a common position, form and course in ten (67%) specimens. Anatomical variations of the precardiac course of the thoracic duct were observed in five animals (33%). Knowledge of these anatomical features should enhance the use of swine as an experimental model.

Keywords: anatomy; lymphatic system; swine

The thoracic duct is the chief collecting vessel of the lymphatic system (Sisson and Grossman, 1956). It conveys lymph from the cisterna chyli to the venous angle (Vollmerhaus, 1981). The cisterna chyli receives lymph from the abdomen, pelvis and hindlimbs. The thoracic duct receives additional lymph from the structures and nodes of the left side of the chest (Dyce et al., 2002) and it is of high importance in thoracic surgery. Thoracic duct lesions are associated with spine trauma, penetrating chest trauma or thoracic surgeries. They can cause thoracic duct leakage resulting in chylothorax which is often described in human and veterinary medicine (Gelzer et al., 1997; Kumar and Ramesh, 2007). Treatment of chylothorax includes catheterization, embolisation and ligation of the thoracic duct. Numerous papers have dealt with the variations of the terminal region and surgical techniques for introducing catheters to collect lymph from the thoracic duct of experimental animals (Vollmerhaus, 1981). The pig is a frequently used animal model due to numerous similarities between human and porcine anatomy and physiology. The use of pigs for teaching purposes in medicine and surgery has increased greatly in recent years, because they are tractable, readily available from commercial suppliers, relatively inexpensive, and generally in good health (Dondelinger et al., 1998). Detailed descriptions of the cisterna chyli and thoracic duct in the pig are scarce in the literature. This work was carried out to provide a detailed description of these structures in the pig which will enhance the use of swine as an experimental model.

MATERIAL AND METHODS

The position of the cisterna chyli, and the origin, course and termination of the thoracic duct were revealed by fine dissection of fifteen porcine carcasses. The porcine carcasses originated from a gross anatomy course at the Department

of Anatomy, Histology and Embryology, Faculty of Veterinary Medicine University of Zagreb, Croatia. The carcasses were fixed with 10% formalin. The study sample consisted of 12 females and three males of Yorkshire pigs with a body mass of 10 to 15 kg and age of 2.5 months. To approach the mediastinum we removed the right and the left thoracic wall, and the right and left lung. Following the fine dissection of the thoracic duct course, the right and left mediastinal pleura were gradually removed. In order to locate the cisterna chyli, incisions in the right and left crus of the diaphragm were made. The macroscopic observations were recorded and photographed.

RESULTS

The cisterna chyli originated at the level of the third lumbar vertebra and the origins of the renal arteries and was covered with the crura of the diaphragm. Its caudal border was positioned to the right and dorsal to the aorta, but cranially it covered the whole dorsal surface of the aorta. It was 6 to 11 cm in length and 0.5 cm in width and was pierced by the first lumbar and last dorsal intercostal arteries or was divided in two parts, one situated left and the other right to the origins of the mentioned arteries, but connected with transverse

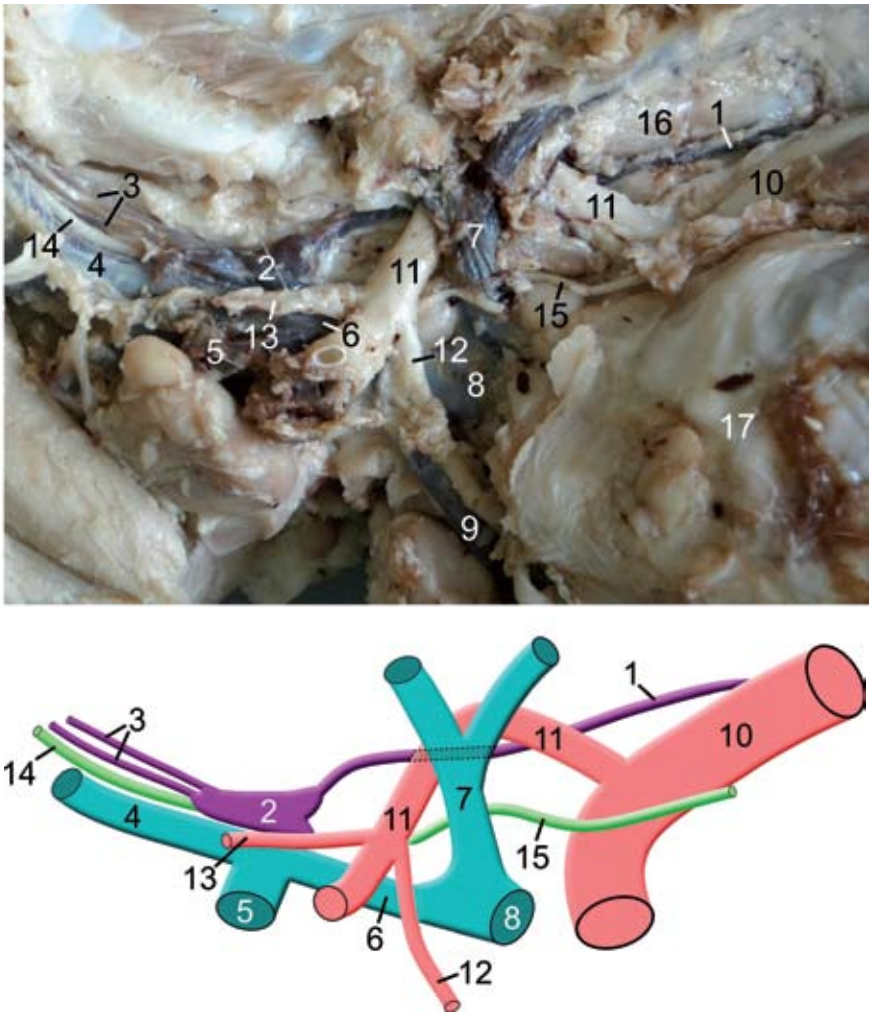

Figure 1. Common precardiac course of the thoracic duct in pig: 1 = thoracic duct (ductus thoracicus), 2 = ampullary termination of the thoracic duct, 3 = double left tracheal duct (truncus trachealis sinister), 4 = left external jugular vein (vena jugularis externa sinistra), 5 = left subclavian vein (vena subclavia sinistra), 6 = left brachiocephalic vein (vena brachiocephalica sinistra), 7 = left costocervical vein (vena costocervicalis sinistra), 8 = cranial vena cava (vena cava cranialis), 9 = left internal thoracic vein (vena thoracica interna sinistra), 10 = aorta, 11 = left subclavian artery (arteria subclavia sinistra), 12 = left internal thoracic artery (arteria thoracica interna sinistra), 13 = left superficial cervical artery (arteria cervicalis superficialis sinistra), 14 = left vagosympathetic trunk (truncus vagosympathicus sinister), 15 = left vagus nerve (nervus vagus sinister), 16 = musculus longus colli sinister, 17 = pericardium

thin vessels ("rope ladder" form). The cisterna chyli terminated at the level of the origins of the 14th or 13th dorsal intercostal arteries, while the thoracic duct arose there and had a much smaller diameter (0.2 cm) than the cisterna chyli. At the level of the 12th thoracic vertebra, the thoracic duct was situated dorsal to the aorta running on the right side of the common trunks of the dorsal intercostal arteries. Each dorsal intercostal artery arose from the aorta with a short common trunk bifurcating in the right and left dorsal intercostal artery. Dorsal to the thoracic duct, there were lymphatic nodes (lymphonodi thoracici aortici) and in some animals the caudal part of the left azygous vein. The thoracic duct ran cranially and slightly ventrally so it appeared at the middle of the right surface of the aorta at the level of the 9th to 6th thoracic vertebra. At the level of the 6th thoracic vertebra the thoracic duct was situated between the right surface of the aorta and the left surface of the esophagus and was no longer visible from the right side. The thoracic duct ran cranially and straight. At the level of the 4th thoracic vertebra the descending aorta extended from the aortic arch. At this level the aorta was positioned ventrally compared to its caudal part, so the thoracic duct, which retained its straight cranial course, appeared again dorsal and left to the aorta. The aortic arch was situated at the level of the 3rd thoracic vertebra and at this level the thoracic duct lost its connection to the dorsal surface of the aorta, ran cranial and straight and was surrounded with fat tissue. It also ran ventrally to the left longus colli muscle (Figure 1) and on the left side of the dorsal surface of the esophagus, crossing the space between the aortic arch and left subclavian artery. The course of the thoracic duct became slightly

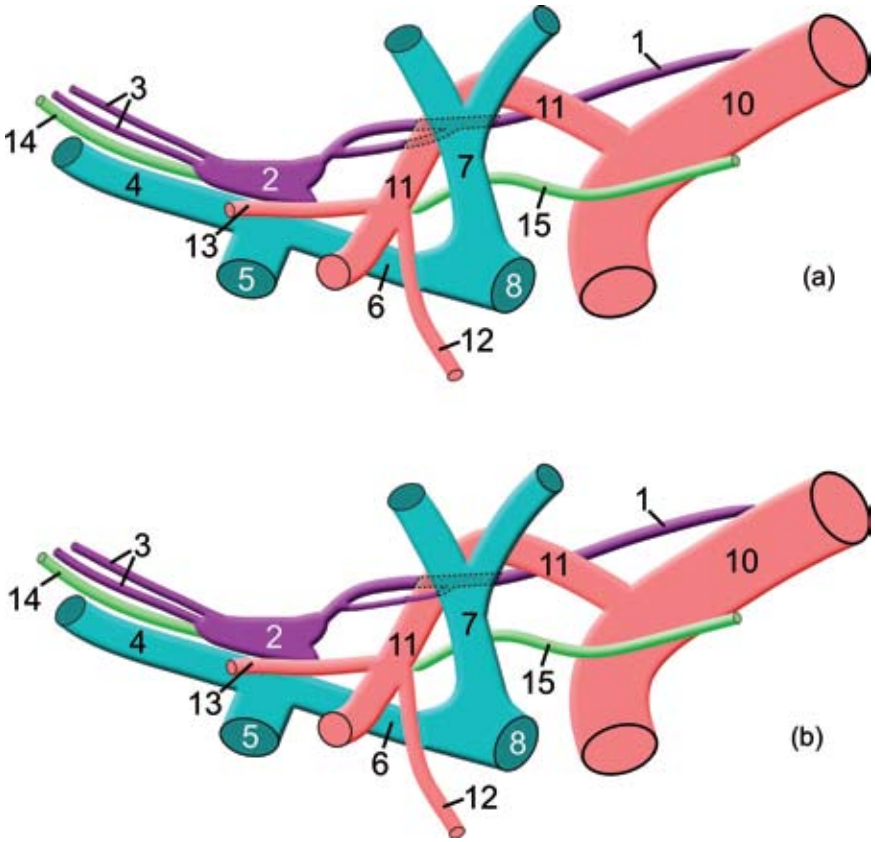

Figure 2. Schematic drawings of anatomical variations of the thoracic duct precardiac course in pig: 1 = thoracic duct (ductus thoracicus), 2 = ampullary termination of the thoracic duct, 3 = duble left tracheal duct (truncus trachealis sinister), 4 = left external jugular vein (vena jugularis externa sinistra), 5 = left subclavian vein (vena subclavia sinistra), 6 = left brachiocephalic vein (vena brachiocephalica sinistra), 7 = left costocervical vein (vena costocervicalis sinistra), 8 = cranial vena cava (vena cava cranialis, 10 = aorta, 11 = left subclavian artery (arteria subclavia sinistra), 12 = left internal thoracic artery (arteria thoracica interna sinistra), 13 = left superficial cervical artery (arteria cervicalis superficialis sinistra), 14 = left vagosympathetic trunk (truncus vagosympathicus sinister), 15 = left vagus nerve (nervus vagus sinister)

cranioventral at the level of the caudal surface of the left subclavian artery. The thoracic duct crossed the left subclavian artery at its right surface, so it was fully covered with the artery being visible again in front of the cranial surface of this vessel at the level of the first rib. Here the thoracic duct was situated ventrally to and partly covered by the middle cervical ganglion and stellate ganglion. In addition, the course of the thoracic duct became steep, cranioventral and parallel to the cranial surface of the left subclavian artery. It passed accross the left surface of the esophagus, vagosympathetic trunk and the left common carotid artery. It terminated with an ampullary dilatation (1 cm in length), medial to the superficial cervical artery (Figure 1). Finally, the ampullary dilatation of the thoracic duct drained into the left external jugular vein at its medial surface. The ampullary thoracic duct termination was situated directly cranial to the junction of the left internal and left external jugular vein, right opposite to the junction of the left subclavian vein to the left external jugular vein.

The above described common course of the thoracic duct was observed in ten animals, while in the remaining five (33%) investigated animals two anatomical variations were revealed within the precardiac course of the thoracic duct. In three animals (20%) the thoracic duct bifurcated into two branches with a similar diameter (ca. 0.1 cm) after reaching the caudal surface of the left subclavian artery. The two branches continued parallel to each other cranioventrally, passing the right surface of the left subclavian artery and united approximately 0.5 cm before termination of the thoracic duct (Figure 2a). In two animals (13%) the thoracic duct bifurcated at the caudal surface of the left subclavian artery, but the course of the two branches separated. One branch, ca. 0.1 cm in diameter, passed the right surface of the left subclavian artery, while the other branch, which was much thinner (ca. 0.05 cm in diameter), passed the left surface of the same artery. Both branches united approximately 0.5 cm before its termination (Figure 2b).

DISCUSSION

Detailed anatomical descriptions of the thoracic duct and cisterna chyli in the pig are scarce. Bearing in mind the intense application of the swine model in experimental medicine, it is important to summarize the published descriptions of these anatomical features. Our findings on the form of the cisterna chyli are similar to the descriptions made by Weidenreich et al. (1933) and Grau (1943), which detailed how cisterna chyli can form islands in pigs. However, a description of size and precise position of the cisterna chili was missing from these reports. Furthermore, our results are consistent with those of Weidenreich et al. (1933), Grau (1943) and Vollmerhaus (1981), who found that the thoracic duct arises from the cisterna chyli as a single trunk in pigs, i.e., the thoracic duct appears as the direct continuation of the cisterna chili, and with those of Vollmerhaus (1981), who found that the right postcardiac segment of the thoracic duct is situated to the right and dorsal to the thoracic aorta and ventral to the right azygous vein. In the literature, there are no precise descriptions on the precardiac course of the thoracic duct in the pig. We observed a common precardiac course in 67% animals and two anatomical variations at the level of the thoracic duct reaching the caudal surface of the left subclavian artery. Grau (1943) noted that the thoracic duct formed an ampullary dilatation at its termination in the horse, cow and dog, but did not mention the pig. According to our findings, ampullary dilatation is a common finding at the termination of the thoracic duct in the pig. As mentioned by Grau (1943), the left tracheal duct typically joins with the thoracic duct immediately before its termination. Variations in the course of the thoracic duct have been well documented in humans (reviewed in Skandalakis et al., 2007). Inoue and Makita (1994) studied variations in the thoracic duct of Japanese monkeys. Eken et al. (2002) concluded that the origin and the course of the thoracic duct in cats do not vary except in the manner of termination. Gomercic and Skrtic (1981) described an inverse position of the thoracic duct in a dog, and Duras Gomercic et al. (2009) recorded an accessory thoracic duct in the same species. Most of the anatomical variations in the pre- and postcardiac course of the thoracic duct are found in the dog (Grau, 1943; Vollmerhaus, 1981). Our findings on the anatomical variations in the precardiac course of the thoracic duct in the pig have to be taken into account during surgical techniques in this species.

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