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Endoscopy of the Thoracic Duct (Lymphoscopy) via the External Jugular Vein in Dogs+

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Summary

A new technique was developed in dogs for direct visualization of the thoracic duct – innominate venous junction. A modified Dyonics needlescope introduced through the left external jugular vein permitted vascular endoscopy (lymphoscopy) with internal cannulation and retrograde lymphangiography of the thoracic duct.

Introduction

Thoracic duct cannulation as usually performed by direct isolation and intubation (similarly to a venous "cutdown") is ordinarily a one-time procedure because of attendant lymphatic obliteration and regional scar formation after removal of the cannula (19,20). To circumvent this problem and allow repeated cannulation of the thoracic duct, a technique was developed whereby the thoracic duct – venous opening was visualized through a rigid endoscope introduced into the venous system*. By optical modification** direct intravascular lymphoscopy and cannulation and lymphangiography through the venous – thoracic duct junction was accomplished.

Materials and Methods

The cervical thoracic duct was isolated in nine mongrel and twelve greyhound dogs after the method of *Witte* et al. (22). Narcosis was induced by intravenous administration of 15-20 ml (50 mg/ml) of nembutal® (Abbott). By isolating the left external jugular vein, exposing the cervical thoracic duct and ligating adjacent cervical veins, venous endoscopy with lymphoscopy, internal cannulation of the thoracic duct and retrograde duct lymphangiography was facilitated. Using a Dyonics** needlescope (diameter 1.7 mm, diameter of cannula 2.4 mm, effective inserting length 100 mm, field of view 90°, depth of field 1.0 mm to infinity, magnification of ocular approximately 30 times, apparent size of observed image about 30 mm, fiber optic light source 3.0 candle power) with needle attachment introduced into the left external jugular vein with side attachment for periodic flushing with isotonic saline, vascular endoscopy was accomplished as the needlescope was advanced along the lateral vascular wall where flow-velocity was minimal (For details on technique see Figure 3 and legend). Photographs of the thoracic duct aperture were taken using Pen F camera with high speed Kodak ektachrome film (EHB 135-36). The cold light supply for taking photographs was ACMI* -FCB 95 Fiber Optic with a fitting for Dyonics needlescope. Internal cannulation of the thoracic duct was accomplished

+ Aided by Deutsche Forschungsgemeinschaft
++ Dedicated Dr. med. H. J. *Koske* to his 65th birthday

after locating the internal duct opening and introducing via a specially designed attachment to the needlescope an intramedic® (PE 90 Clay-Adams) polyethylene tubing (outer diameter 1.25 and inner diameter 0.75 mm) or silastic tubing (19, 20). The catheter was secured with a circumferential ligature of fine silk around the thoracic duct. Lymph was collected by gravity drainage and samples examined following inguinal lymphangiography (after method of *Abernathy* et al.[1]) and infusion of Evans Blue® (*Warner-Chilcott*) into an inguinal lymphatic. Retrograde Lymphangiography*** of the thoracic duct was accomplished after both infusion of physiologic saline slowly in retrograde fashion as well as distention of a Blakemore-Sengstaken tube previously placed in the esophagus and stomach according to the method of *Jünemann* (11, 12).

Results

Figure 1 illustrates the anatomy of the cervical thoracic duct in nine mongrel and nine greyhound dogs with the preterminal lymph cistern and branches of the thoracic duct entering the left innominate vein at a relatively acute angle. Through the venous endoscope, it was possible to distinguish venous tributaries from lymphatic apertures often lying adjacent to one another (Figs. 4 and 1, see T8, T12, T14, T16) and to observe the piston-like, respiration-related expulsion of chylous or vital-stained lymph (after Evans Blue® dye had been previously injected into an inguinal lymphatic) into the venous system. By placing the attachment tip close to the venous wall and infusing a continuous saline drip through a "side-arm" lumen, a clear image of the venous wall was achieved (Fig. 4). The image was inverted and enlarged 10-20 times, depending upon the optical system. Photographs sometimes were facilitated by ligating cervical veins lying close to the thoracic duct opening.

Thoracic duct cannulation under close view control was highly successful in six greyhounds using selected pre-bent stainless steel tubing (Figs. 3a and 3b) adapted to the angle between the terminal thoracic duct and the innominate vein. On one occasion, the catheter was inserted via the preterminal lymph cistern into a cervical lymph vessel. On two other occasions, the thoracic duct wall was perforated just below the terminal lymph cistern resulting in leakage of lymph and later contrast media. In four other experiments, the catheter could not be inserted beyond the thoracic duct opening because of angulation of the innominate vein. On two occasions, resistance to passage of the cannula into the thoracic duct was localized to a small sized annulus-like terminal lymphatic valve. This 1 mm diameter obstacle only allowed passage of thin, guidable wires.

Retrograde x-ray visualization of the thoracic duct after external fixation of the catheter by ligature proved successful after preliminary retrograde rinse with physiologic saline at a slow drip for 30 minutes. Approximately 20 ml of water soluble contrast media (Angio-Conray®, Biligram®) was optimal as larger volumes did not improve visualization. Both contrast media mixed well with the lymph. A raised injection pressure ran the risk of lymph and contrast medium leakage (Fig. 2b). Without preliminary perfusion of saline, contrast media emptied into cervical lymphatics and drained into the innominate vein and superior vena cava. Following the rinse manoeuver, the thoracic duct was visualized by instillation of contrast x-ray media down as far as the 6th-8th vertebrae and the dia-

* Selfoc Hi-scope (Olympus Optical Co. (Europa) GmbH, 2000 Hamburg 1, Steindamm 105, Federal Republic of Germany) and ACMI-Pediatric Cystoscope (American Cystoscope Makers, Inc., 8 Pelham Parkway, Palham Manor, N.Y. 10803, USA

** Dyonics needlescope with right angle optics (Dyonics Corp., 71 Pine Street, Woburn, Massachusetts 01801, USA

*** With Angio-Conray® (Mallinckrodt), Biligram® for injection (Schering) and Ethiodol®

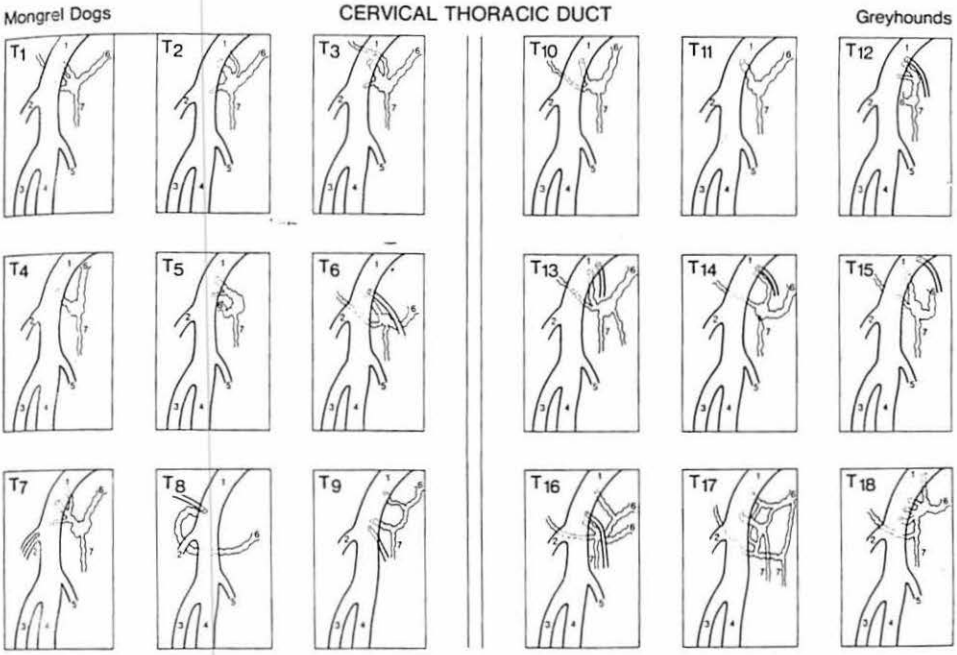

Fig. 1 The anatomy of the cervical thoracic duct of 9 mongrel dogs and 9 greyhounds shows the variations, branches and preterminal lymph cistern at the entrance of the cervical lymph vessels. 1 = Vena innominata; 2 = Vena subclavia; 3 = Vena jugularis externa; 4 = Vena jugularis interna; 5 = Vena thyreoidea inferior; 6 = Ductus thoracicus; 7 = Vas lymphatica cervicalis.

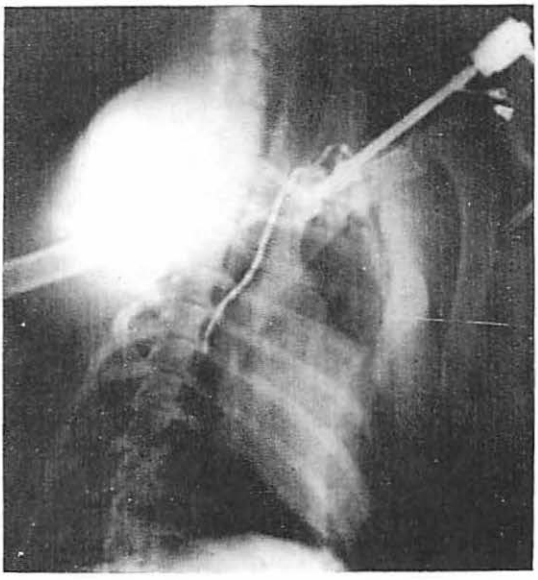

Fig. 2a X-ray showing retrograde filling with Angio-Conray® of the thoracic duct, preterminal lymph cistern and a cervical lymph node via Dyonics needle-scope. See Fig. 1, T 14.

Fig. 2b X-ray showing retrograde thoracic duct filling with Ethiodol® and contrast medium leakage (see text).

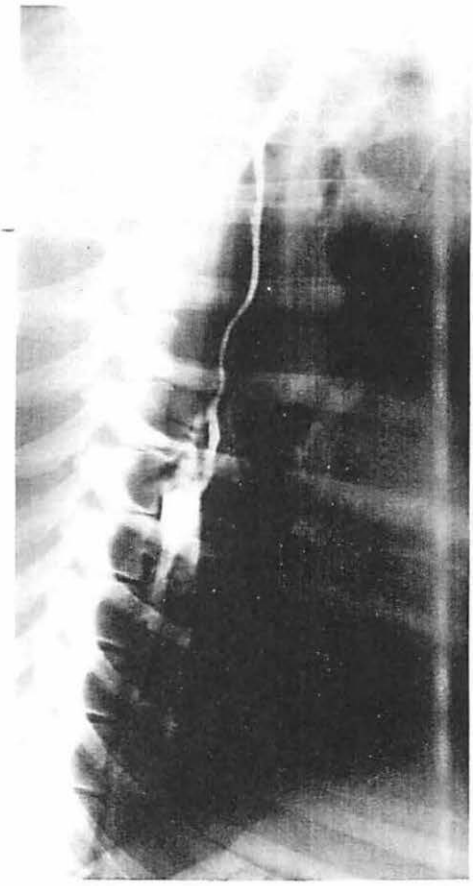

Fig. 2c X-ray showing retrograde thoracic duct filling with Angio-Conray® to the level of the diaphragm.

phragm (Fig. 2). Lymphatic branching or lymphovenous anastomoses were not seen in these experiments. Arresting intra-abdominal lymph flow by inflation of a Blakemore esophageal tube balloon in the stomach or esophagus facilitated retrograde visualization of the thoracic duct to its origin at the diaphragm. Several minutes later, water soluble contrast medium could be seen in the azygos vein and the superior vena cava.

Using "fast" inguinal lymphangiography (injecting by hand 10 ml of Angio-Conray®, followed by an inguinal lymph vessel injection of 10 ml of physiologic saline within 20 minutes (via Multi-Speed Transmission Pump, Serial No. 25073, Harvard Apparatus Co., 150 Dover Road, Millis, Mass. 02054), contrast medium was almost totally recovered from the internal lymph fistula (13.3 ml of lymph within 30 minutes). Ten to twenty minutes after initiating inguinal lymphangiography plain films of the abdomen showed no contrast medium excreted by the kidneys, a finding normally present at this point in time after infusion into an inguinal lymphatic.

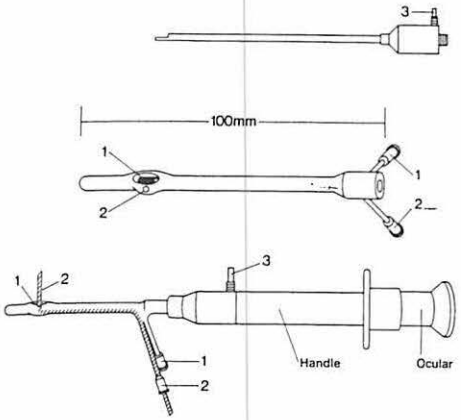

Fig. 3a The Dyonics needlescope with an ultrafine optical needle (above) and fiberoptic illumination (3) for direct 90° viewing enables an endovascular observation of venous and thoracic duct lumina. Saline-flushing via a Luer-fitting (1) forms a "transparent saline rinsing medium" between optics and vascular wall.
The scope is introduced into the external jugular vein with its attachment (medium). This oval shaped sheath of stainless steel encloses the optical needle and a pre-bent tubing (2) to guide a polyethylene tubing.

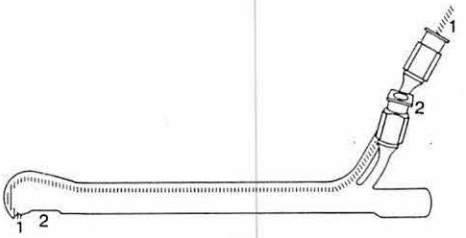

Fig. 3b Via the more pre-bent tubing (1) of this attachment a polyethylene tubing can be guided in those cases where a sharper angle exists between the terminal thoracic duct and the innominate vein.

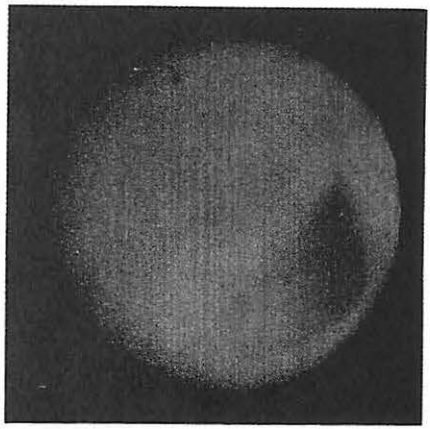

Fig. 4a Coloured photo (original photo is enlarged 5 times) of a thoracic duct opening into the left innominate vein of a greyhound. In this case an acute angle existed between the terminal thoracic duct and the innominate vein (see Fig. 1, T 15).

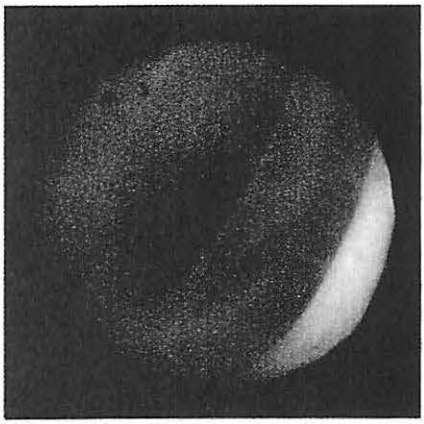

Fig. 4b In this case the right angle optics enabled direct observation of the cervical lymphovenous junction with the terminal thoracic duct valve.

Similarly, introduction of Evans Blue® via an inguinal lymphatic (using a lymphatic pump, 10 ml of 0.25% aqueous soluted Evans Blue® was injected within 10 minutes followed by 50 ml saline over the next 50 minutes) produced within four minutes blue-stained lymph samples from the internal lymph fistula. For the next 60 minutes, the lymph color changed from deep blue to medium blue to light blue and finally became chylous suggesting almost quantitative collection of blue dye from the duct fistula (Fig. 5).

Fig. 4c The thoracic duct opening lies close to a cervical vein opening (left side) (see Fig. 1, T 14).

Fig. 4d After ligature of the cervical vein (see Fig. 4c, left side) the coloured photo demonstrates the thoracic duct opening (right side) with cervical vein collapsed.

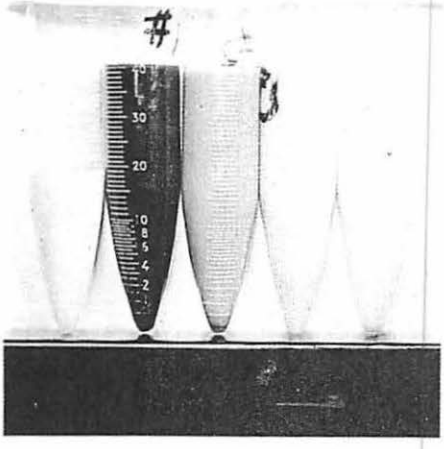

Fig. 5 The first tube shows normal chylous lymph. After performing a "fast" inguinal lymphangiography with Evans Blue® (see text) the following 15 minutes lymph probes are dyed deep blue (2nd tube), medium blue (3rd tube), light blue (4th tube) and the last one is once again chylous.

Discussion

Using the modified Dyonics needlescope, the orientation in locating and relocating venous or thoracic duct apertures is simplified as the scope' s stainless steel attachment may be freely rotated or moved to and fro. Although internal cannulation of the thoracic duct was achieved in this manner, satisfactory retrograde lymphangiography and complete sampling of lymph required "binding" of the thoracic duct lumen with ligatures. This manoeuver may be obviated in the future by development of a modified Swan-Ganz catheter with an attached balloon for inflation to compress the duct temporarily.

This study corroborates the anatomic variance of the terminus of the cervical thoracic duct (15, 17), including the relatively sharp angle of the thoracic duct – innominate vein junction. The sharp angulation necessitates using a right angle endoscopic optic system to visualize the internal thoracic duct opening. As has been previously noted, synchronous with respiration, venous blood often refluxes up to the "final" lymphatic valve (13). Perhaps the narrowness of these terminal lymphatic valves in conjunction with the close proximity of the thoracic duct and the preterminal lymph cistern to the carotid artery combines to generate a cyclic lymph-venous pressure gradient accounting for the piston-like emptying of lymph into the venous system.

Dilators (analogous to miniature Hegar tubes) too may be made available in the future to overcome valvular resistance and, pressure transducers may then be introduced through more suitable lymphoscopes (Fig. 6) to record pressure dynamics and fluctuations in pressure with changes in lymph flow. A "percutaneous transjugular lymphoscopic thoracic duct cannulation" is plausible via a Y-shaped vascular Dacron patch inserted into the external jugular vein of animals.

Internal cannulation of the thoracic duct from the venous side has distinct potential advantages over current methods. This technique provides a valuable tool to study in vivo the normal and pathologic structure and function of the intact thoracic duct – venous junction. Serial retrograde lymphangiography (enhanced if necessary by esophageal balloon inflation) may reveal morphologic changes of the mediastinal thoracic duct and lymphatic tributaries in the course of a variety of disease states, particularly malignancies involving the lymphatic system (6). Moreover, transvenous lymphoscopy with internal thoracic duct cannulation allows repeated serial measurements of the flow and composition of thoracic duct lymph for the diagnosis of pathologic conditions (4, 10), prognosis (7), and treatment by interception and diversion of harmful foreign substances (2, 14, 16) or metabolic waste products absorbed and transported in the lymphatic system (5, 9).

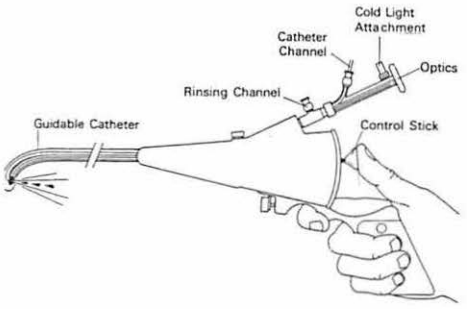

Fig. 6 Rough design of a flexible lymphoscope using a guidable Medi Tech Selector catheter (*Cooper* Scientific Corp., 372 Main Street, Watertown, Mass. 02172) (18) as a tubing for a catheter and a right angle and wide-field optics system.

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A New Technique for Cannulating Lymphatic Vessels: Experience in 150 Extremities

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Summary

A simple new instrument designed to automatically direct the needle into the lumen of a lymphatic duct has been developed. Experience with this new technique for cannulating lymphatic vessels is reported in 150 individual extremities. The cannulator reduces the time, skill and effort currently required for needle placement.