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# Measurement of Lymph Flow of the Heart*

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The intrinsic lymphatics of the heart consist of subendocardial, myocardial and subepicardial plexuses. Collecting channels lie in the atrioventricular sulcus and two main trunks drain roughly the left and right sides of the heart (1, 2, 3). *Patek* (1) noted that these two trunks form a single trunk which lies on the pulmonary artery. *Symbas* (3) made *in vivo* studies and described separate courses to the mediastinum of the left and the right trunks. A third trunk lies posteriorly and drains part of the posterior myocardium (4). Above the roots of the aorta and pulmonary artery the number of lymphatics pathways and interconnections vary considerably as illustrated by *Allison* and *Sabiston* (4).

In our own experience with more than 75 dissections of the mediastinum, the number and location of lymphatics and lymph nodes was variable, particularly at the level exposed through the left 3rd or 4th intercostal space. A single lymph node between the superior vena cava and brachiocephalic artery with two lymphatic channels entering it was encountered in more than half of our animals, however, not infrequently three or four lymph nodes and up to four or five lymphatic channels were seen. When the mediastinum was exposed through a right chest incision (through the 3rd or 4th intercostal space), the lymphatics were less variable. Usually two lymphatics could be seen crossing the right side of the arch of the aorta and cannulation of one of them was carried out at this point. Usually one or two lymph nodes, rarely three or more, were located between the trachea and the superior vena cava, or were in proximity to the arch of the aorta.

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*Drinker* (5) presented evidence that the cardiac lymph flow passes through the right lymphatic duct. We have noted (6) that radioactive iodinated albumin placed in the pericardial sac, which is drained through the cardiac lymphatics (7), is recovered from both the right duct and the thoracic duct. There is a different proportion in each animal, possibly due to anatomic variations in the lymphatic channels, particularly those in the mediastinum.

Several investigators have measured the canine cardiac lymph flow (8, 9, 10, 11, 12). One is impressed by the differences obtained by these investigators (Table 1). It is the purpose of this discussion to attempt to interpret the reported lymph flows in the light of our present knowledge of the anatomy and function of the lymphatic trunks which drain the heart and course cephalad in the mediastinum.

Table 1 Mean Cardiac Lymph Flow of Normal Dogs.

| Authors | BW Kg | Heart wt. gm | Cardiac lymph flow ml/hr | Cardiac lymph flow ml/gm/hr | Surgical approach | Par-enteral fluids |
|---|---|---|---|---|---|---|
| Drinker, Warren,Maurer, McCarell, 1940 | 12.0 (10) | 95.5 (10) | 0.8 (10) | 0.0087 (10) | trans-sternal | given |
| Miller, Ellis, Katz, 1964 | 17.7 (13) | | 3.2 (13) | | left intercostal | given |
| Areskog, Arturson, Grotte, 1964 | 18.0 (8) | 124.0 (8) | 1.9 (8) | 0.015 (8) | trans-sternal | |
| Uhley, Leeds, Sampson, Friedman, 1969 | 21.38 (6) | 162.0 (4) | 2.28 (6) | 0.011 (4) | left intercostal | not given |
| Leeds, Uhley, Sampson, Friedman, 1970 | 16.7 (20) | | 1.2 (20) | | right intercostal | not given |

The number of experiments in parentheses.

The smallest flow of 0.8 ml/hr was obtained in 10 dogs by *Drinker* et al. (10) who used a trans-sternal approach. The largest flow of 3.2 ml/hr was reported by *Miller* et al. (12) in 13 dogs in which a left intercostal incision was employed. "All other discernible lymphatics draining the heart were ligated" by the latter authors. Intermediate flows were obtained in our laboratory (8, 9) and by *Areskog* et al. (1.9 ml/hr in 8 dogs) (11). *Areskog* et al. employed a mass ligature around the soft tissues above the lymph glands situated between the superior vena cava and the brachiocephalic artery. The glands lie about 2 cm above the base of the heart. In 6 normal dogs reported by us, in which a left intercostal incision was made, the mean cardiac flow was 2.28 ml/hr (8). A right intercostal approach was required in a second series of our experiments because it gave access to the coronary sinus which we wished to ligate. The mean cardiac lymph flow was 1.2 ml/hr in 20 normal dogs in this series (9). The mean values of the two groups of experiments were subjected to statistical analysis and found to be statistically different with $t = 3.01$ at the significant level $p < 0.05$.

Why is the mean cardiac lymph flow 1.2 ml/hr when a right sided approach is used and almost double (2.28 ml/hr) when the approach is from the left? When a right sided approach is employed, a lymphatic very near the heart is cannulated where it lies on the right side of the proximal aortic arch. With a left sided approach the lymphatics which are visualized lie on the trachea above the left side of the aortic arch and are more distant from the heart (Fig. 1). Although there is great variability in location, size and number of mediastinal lymphatics and their relation to the lymph nodes, the flow rates were in a reasonably narrow range when a single lymphatic was cannulated at approximately the same level above the heart.

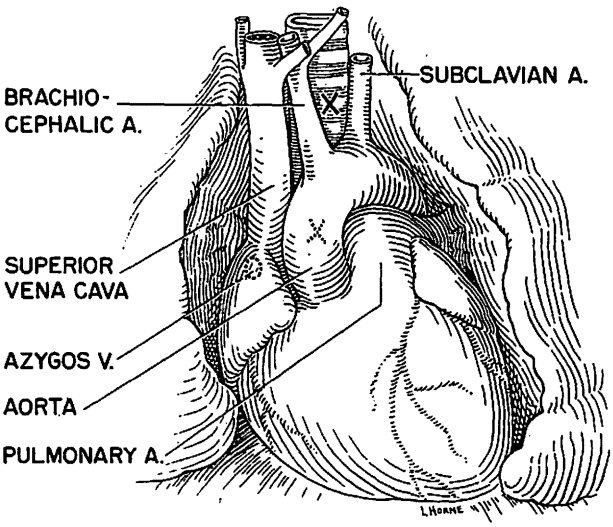


Fig. 1
Drawing to show levels cephalad to heart at which a cardiac lymphatic channel was cannulated. The solid X represents the level exposed through a left 3rd or 4th intercostal incision and the dotted X represents the level at which cannulation was performed, usually through a right 4th intercostal approach.

On the right side, the point of cannulation is not far cephalad from the main lymphatic trunk which drains the right side of the heart (3, 4). It seems certain that this lymphatic drains mainly the right ventricle. This supposition is supported by the anatomical studies quoted. It is also supported by the fact that dye (T-1824), when injected into the right ventricular myocardium, appears promptly in the lymphatics described. There is some evidence, however, that these lymphatics which mainly drain the right heart, also receive lymph from the left side of the heart. In the experiments in which the coronary sinus was ligated, producing venous congestion principally of the left ventricle (13), the lymph flow from a lymphatic trunk which presumably drains mainly the right heart, was appreciably increased (9).

When the mediastinal lymphatics are approached through the third or fourth left intercostal incision, those which are visualized and cannulated in our experiments lie well above the heart and aortic arch. At this distance from the heart, lymph from a number of channels must certainly drain into the cannulated lymphatic. The lymph can come from the right, left and posterior trunks described by *Patek, Allison* and *Sabiston* and others, and possibly from other lymphatics besides those intrinsic to the heart. Hence a higher flow is recorded than when the cannulated lymphatic is nearer to the heart. The possibility that lymph from other structures besides the heart contribute to the flow

at this level needs further investigation. Subsidiary routes which drain the peritoneal cavity run up in the mediastinum to the bronchial lymph nodes (7) and possibly may connect with mediastinal channels which drain cardiac lymph. Furthermore, since usually more than one lymphatic is present at this level, it is possible that some cardiac lymph passes through collateral channels and is not recorded.

Some of the differences in cardiac lymph flows obtained in the several laboratories quoted may depend on differences in techniques. Ligation of all other visible lymphatics in the mediastinum by *Miller* et al. and mass ligation of mediastinal soft tissue by *Areskog* et al. may have altered the flow rate. Other factors, particularly the condition of the heart, may have contributed to the extremes of flow which were encountered. Maintenance of the animal in good functional condition with a minimum of manipulation of the heart is of course essential to satisfactory studies of cardiac lymph flow.

There is still much to be learned about the pathways of the mediastinal lymphatics and their place of emptying into the venous system. However, it appears that the nearer to the heart that the cannulation is carried out, the lower the flow, presumably because fewer lymphatics which drain the heart (and possibly other structures) contribute to the flow. With further knowledge of the mediastinal lymphatic channels the cardiac lymphatic flow will be better understood.

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