

## THE LYMPHATICS OF THE CANINE PARIETAL PERICARDIUM

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### ABSTRACT

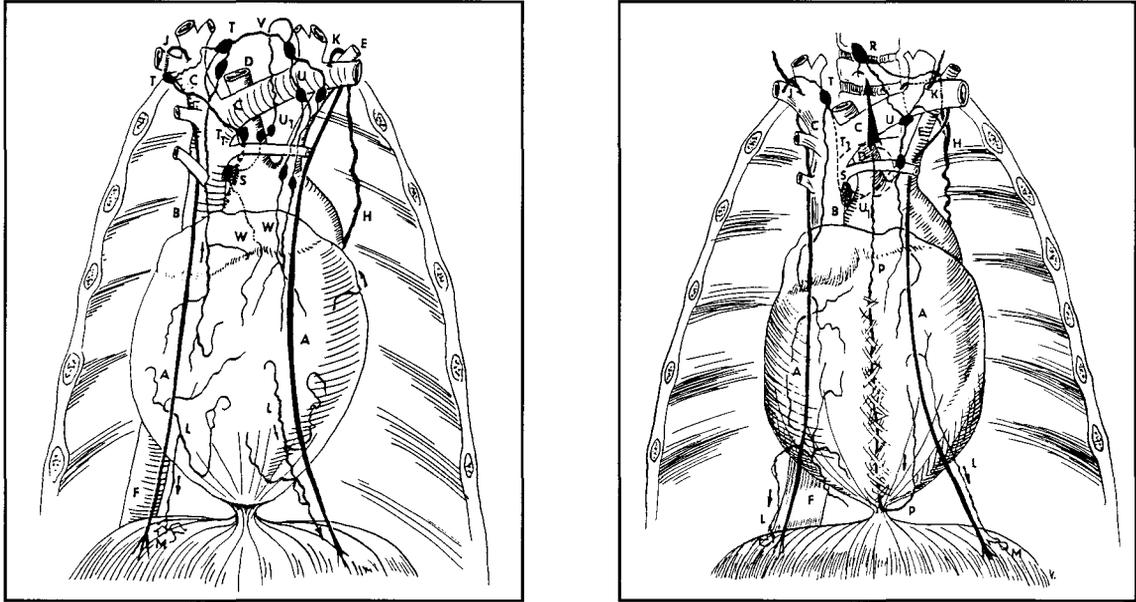
*A careful anatomical study of the lymphatic drainage from the parietal pericardium reveals a complicated network that is notably different from that defined by the instillation of markers into the pericardial sac. The pericardial cupola and the posterior (dorsal) area of the parietal pericardium drain directly to the cardiac lymph node in the right upper mediastinum by relatively short lymphatics. The lymphatics of the anterior and lateral areas of the parietal pericardium pass to collecting vessels that travel cranially or caudally along the phrenic nerves. The former traverse specific lymph nodes and then enter the right or left venous angles. The latter pass caudally and then drain to the major collecting systems from the area of the diaphragm.*

In previous communications our studies of the morphology of the lymphatic vessels draining the dog heart have been presented in detail, along with reviews of the pertinent literature (1-11). In our reviews we have found scant information on the lymphatic drainage of the parietal pericardium, though Ellenberger and Baum, in 1891, and Baum, in 1918, reported partial studies (2,3). Most studies, as detailed by Miller in 1982 (12), and then further reported by Miller et al (13) in 1988, have described pathways of removal of substances that were instilled into the pericardial sac. Such studies are not directed at detailed anatomical characteristics.

Accordingly, we undertook to study further the anatomical lymphatic pathways draining the parietal pericardium in the dog.

### MATERIAL AND METHODS

We studied 28 mongrel dogs (body weight 18 to 30 Kg). After general anesthesia was instituted and tracheal intubation accomplished, the chest was opened via a sternal-splitting incision. A suspension of India ink in 2 percent gelatin heated to 45°C was then injected into the interstitium of the pericardial wall between the fibrous and submesothelial layers. After the lymphatic vessels were visualized, a needle 250 µm in width was carefully introduced into the lumen of various visualized lymphatics and additional injections of India ink in 2 percent gelatin were made directly into the lymphatics to visualize further their pathways. Each of these intralymphatic injections was with 0.1 to 0.2 ml of the India ink in gelatin suspension. For effective visualization of these very fine pericardial lymphatics, 20 to 30 intralymphatic injections were usually made with the aid of the dissecting microscope. The injection sites were on the anterior and lateral pericardial surfaces, and in the pericardium that was close to the diaphragm. In this way, the courses of the lymphatic vessels were followed as far as their terminations into respective lymph nodes. When the injections were completed, photographs were taken and then the pericardium was fixed in 10 percent



*Fig. 1. Patterns of lymphatic drainage from the anterior aspect of the parietal pericardium. A=phrenic nerve; B=superior vena cava; C=right and left brachiocephalic veins; D=brachiocephalic artery; E=left subclavian artery; F=inferior vena cava; G=azygos vein; H=thoracic duct; J=right venous angle; K=left venous angle; L=lymphatics draining towards diaphragm; M=lymphatic network of the diaphragm; N=tracheobronchial nodes; P=parasternal lymphatics, passing to the sternal node (arrow); R=sternal node with efferents passing to the left venous angle; S=cardiac lymph node; T=right superior anterior mediastinal nodes; T1=communication with the cardiac lymph node; U=left superior anterior mediastinal nodes; U1=communication with the cardiac lymph node; V=interconnection right and left venous angles; W=lymphatics of the pericardial cupola.*

formalin solution, dehydrated in alcohol and cleared in methyl salicylate.

In order to facilitate descriptions of the pericardial vessels in the dog, we divided the pericardium into geographical areas as follows:

- A) Lower anterior area: The caudal ventral surface between the two phrenic nerves.
- A') Upper anterior area: The cranial ventral surface between the two phrenic nerves.
- B) Lateral areas: Dorsally from the phrenic nerves as far as the pulmonary veins.
- C) Lower Posterior area: Corresponding to the human diaphragmatic region.
- C') Upper posterior area: The regions of the oblique and transverse sinuses.

### *General Observations*

In contrast to man, the canine pericardium is not attached as firmly to the diaphragm at its inferior (diaphragmatic) surface. In the standing dog, the heart hangs with its long axis in a dorsoventral direction, with the apex adjacent to the diaphragm at its sternal insertion. Thus, in the dog, the pericardial area corresponding to the human diaphragmatic portion is covered by the right and left mediastinal pleura.

The diameter of the pericardial lymphatics ranged between 100 and 400  $\mu$ m. The lymphatic collectors along the phrenic nerves varied from 0.5 to 1.0 mm in thickness. Lymph node sizes depended on the weight of the dog, varying between 2.0 and 10.0 mm in diameter. The cardiac lymph node generally

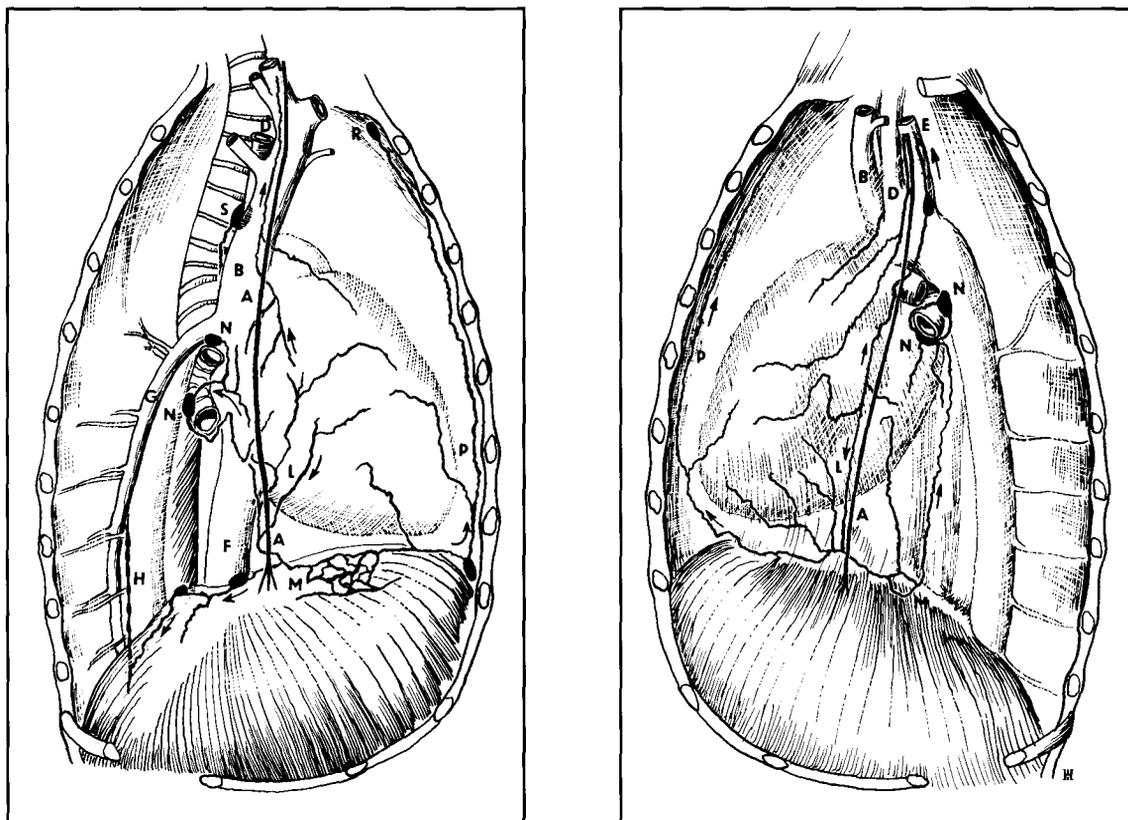


Fig. 2. Lymphatic drainage of a) right lateral and posterior aspect of the parietal pericardium and b) left lateral and posterior aspect of the parietal pericardium. (See Fig. 1 for abbreviations)

was between 1.0 and 2.0 cm in diameter. The tracheobronchial nodes were sometimes as large as 3.0 cm in diameter.

#### *The Lymphatics of the Anterior Area (see Fig. 1a and b)*

Injection of lymphatics in the anterior area revealed them initially to run laterally, towards the right and left phrenic nerves.

A) From the lower part of the anterior area, the lymphatic vessels, together with the pericardiophrenic vessels, ran caudally along the phrenic nerve towards the diaphragm.

1) Paralleling the right phrenic nerve, a lymphatic passed towards the ventral aspect of the inferior vena cava. A small intercalated lymph node was occasionally seen at the foramen venae cavae. Then the

lymphatics passed along with the branches of the phrenic nerve to enter the diaphragm. In the diaphragm the lymphatics ran between the muscle bundles, occasionally reaching the abdominal diaphragmatic surface. From the diaphragm the lymphatics passed either dorsally towards the aorta to enter the cisterna chyli or thoracic duct or ventrally towards the sternum to enter the parasternal lymphatics.

2) In approximately one-half of the dogs, a lymphatic ran caudally adjacent to the left phrenic nerve to enter the diaphragm, and then passed dorsally in a pleural fold to form a network of lymphatics. From this network, a lymphatic vessel passed cranially, through the pulmonary ligament, around the root of the lung, to enter the inferior and left superior tracheobronchial nodes. In one dog, the lymphatic ascending from the diaphragm

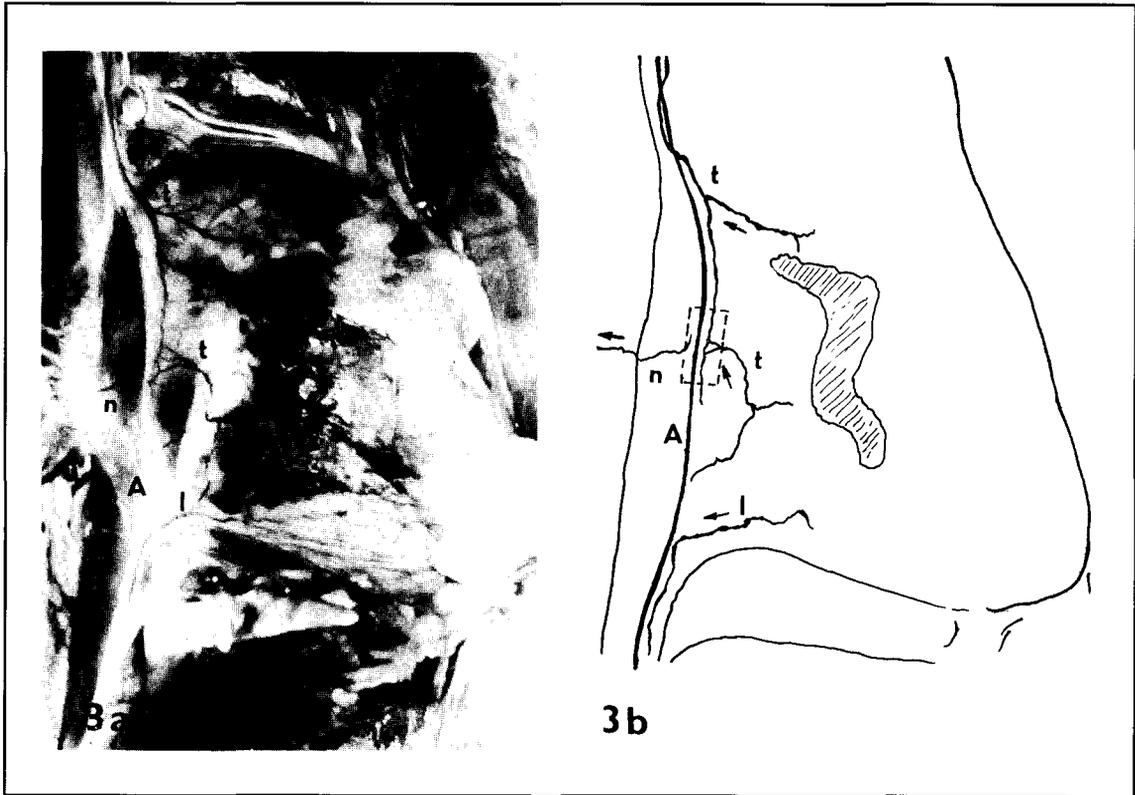


Fig. 3. Photograph (a) and schema (b) of India ink injected lymphatics on the right dorsolateral part of the pericardium. Black spots are sites of interstitial pericardium injections of India ink. A=phrenic nerve; l=lymphatics draining to the diaphragm; n=communication with the right tracheobronchial nodes; t=lymphatics from the upper part of the pericardium running along the phrenic nerve to the right anterior superior mediastinal nodes; u=lymphatics from the upper part of the pericardium running along the phrenic nerve to the left anterior superior mediastinal nodes; p=lymph vessel joining the parasternal lymphatics; bv=blood vessel; v=vein.

passed along the right phrenic nerve to the left aspect of the inferior vena cava, and then passed upwards to the inferior and right superior tracheobronchial nodes. In the other half of the dogs, both the lymphatics along the left phrenic nerve and the lymphatics from the left lower portion of the anterior pericardial surface passed ventrally and caudally towards the sternum through the mediastinal connective tissue. Near the sternum these lymphatics joined the internal thoracic vessels and ascended, as did the left parasternal lymphatics, as far as the second rib to enter the sternal lymph node.

3) The lymphatic vessels running caudal along the phrenic nerves often

interconnected, with transverse anastomoses passing to the parasternal lymphatics. In most instances only one parasternal lymphatic collector was present, receiving lymphatics from both sides of the anterior surface of the pericardium.

A') The upper half of the anterior area of the pericardial surface was drained by lymphatic vessels running laterally, and then passing cranially along the phrenic nerve.

1) On the right, the lymphatics followed the course of the superior vena cava and opened into the superior right anterior mediastinal nodes, situated in the angle between the brachiocephalic veins. The caudal

node of this group, located between the lower margin of the left brachiocephalic vein and the left aspect of the superior vena cava, often communicated with the cardiac lymph node. From the superior right anterior mediastinal nodes, lymphatic vessels passed upward and to the right, crossing the right internal thoracic vessels and the right brachiocephalic vein, to enter the right venous angle.

2) On the left side, the lymphatics passed upwards along with the phrenic nerve towards the lower lymph node of the left anterior mediastinal nodes situated on the convexity of the aortic arch between the origin of the brachiocephalic artery and the left subclavian artery. They entered that lymph node, or bypassed it and ascended along the left subclavian artery. The latter lymphatics entered the superior left anterior mediastinal nodes, a group of nodes situated behind the left subclavian vein.

a) In 45 percent of instances, efferent lymphatics emerging from the superior left anterior mediastinal nodes passed to the nodes above the left brachiocephalic vein, and then ran crossways to the right to enter the right venous angle.

b) In 55 percent of instances, efferent lymphatics emerging from the left anterior mediastinal nodes linked directly to the thoracic duct, or traveled via the left bronchomediastinal trunk directly to the left venous angle.

c) There were usually interconnections between the two ascending lymphatic systems in the area of the cardiac lymph node.

d) From the ventral area of the pericardial cupola, lymphatics ran sideways to enter lymphatics paralleling the phrenic nerves. Short lymphatic vessels connected to the cardiac lymph node.

#### *The Lymphatics of the Lateral Pericardial Areas (see Figs. 2a and b, 3 to 7)*

B) The *lateral areas of the pericardium* dorsal to the phrenic nerves drained to lymphatic vessels that paralleled the phrenic



Fig. 4. Detail of blocked area on Fig. 3. Lymphatics (arrows) in this cleared specimen are seen passing along blood vessels, which are filled with blood. Original magnification 4x. A=phrenic nerve; v=vein.

nerves both cranially and caudally. The area of the pericardium in front of the pulmonary veins was drained by short lymphatics that encircled the veins and then passed to the right or left tracheobronchial nodes, respectively.

#### *The Lymphatics of the Posterior Pericardial Areas*

C) Lymphatic vessels from the *lower (caudal) part of the posterior pericardial area* passed either laterally towards the right and left phrenic nerves or anteriorly through the mediastinum to open into lymphatics passing cranially along the sternum.

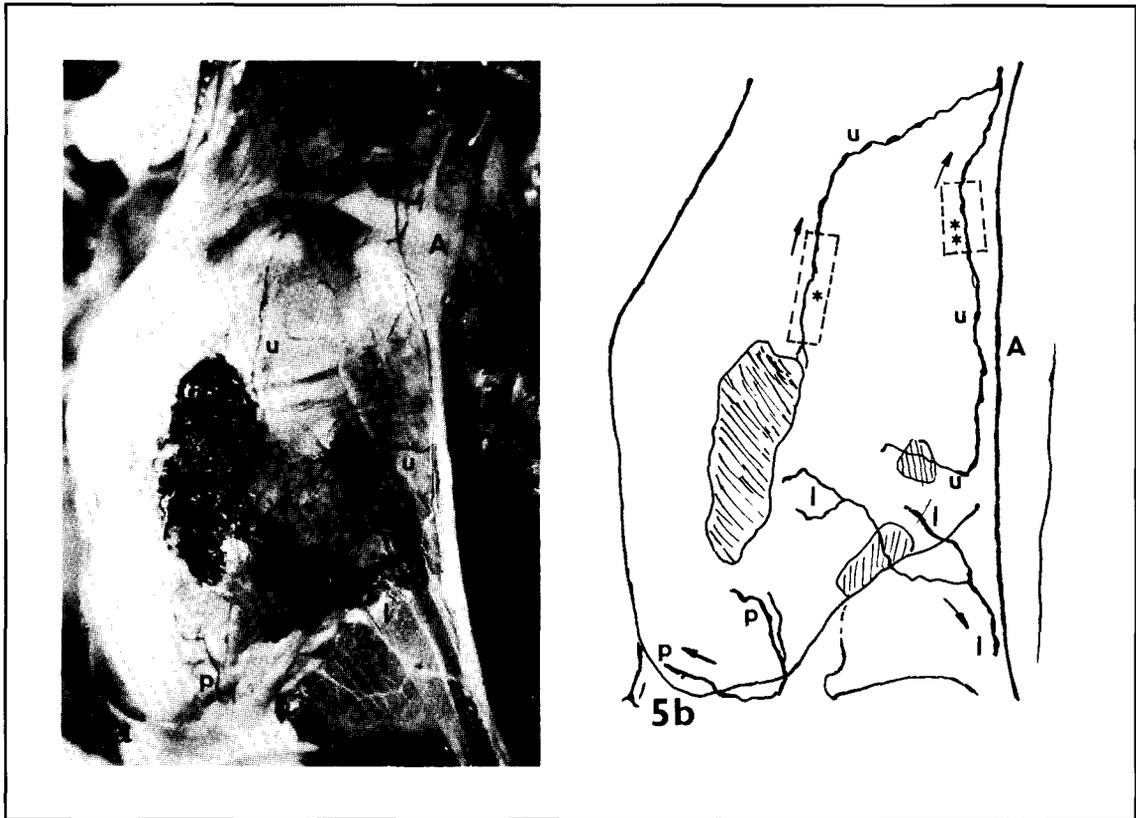


Fig. 5. Photograph (a) and schema (b) of India ink injected lymphatics on the left dorsolateral part of the pericardium. See Fig. 3 for abbreviations.

C') From the area of the *upper posterior part of the pericardium*, the lymphatics traveled as fine vessels cranially to inferior right and left superior tracheobronchial nodes, respectively, and from these nodes to the cardiac lymph node.

#### DISCUSSION

The anatomy of the lymphatic system draining the parietal pericardium in the dog is rather complicated, but can be reasonably generalized to make it more understandable. The pericardial cupola and the posterior (dorsal) area of the pericardium drain directly to the cardiac lymph node by relatively short lymphatics. The lymphatics of the anterior and lateral areas of the parietal pericardium

pass to collecting vessels that travel cranially or caudally paralleling the phrenic nerves. The former, passing via certain lymph node groupings, enter the right or left venous angles. The latter, passing caudally, drain to the major collecting systems from the area of the diaphragm.

It is apparent that the lymphatic drainage system of the parietal pericardium as described here is considerably different than the lymph drainage system that is visualized by instilling materials (e.g., India ink, micropulverized barium sulfate) into the pericardial space (12,13). In the latter situation, drainage of the marker is via the epicardial surface vessels of the heart, as well as from the parietal pericardium. Thus, drainage from the pericardial space (between



Fig. 6. Detail of blocked area (\*) on Fig. 5(b). Lymphatics (arrows) in this cleared specimen are seen passing along veins, which are partially filled with blood. Original magnification 4x. v=vein.

the surface of the heart and the parietal pericardium) can be thought of as basically a "physiologic" experiment that demonstrates the function of both the parietal and visceral pericardial surfaces as active in the removal of substances (e.g., protein, macromolecules) from the pericardial space. Completely different data are here offered in the description of the detailed anatomy of the parietal pericardium. We believe it likely that the anatomy described for the parietal pericardium in the dog is similar to that found in man.

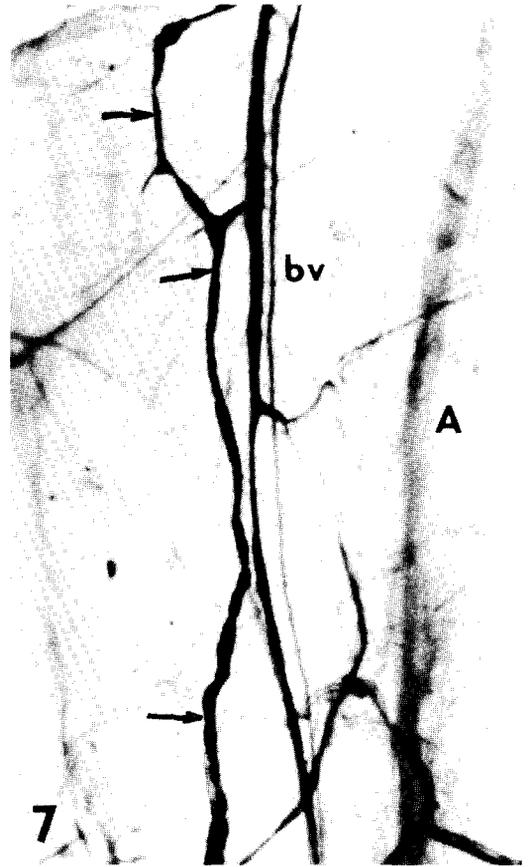


Fig. 7. Detail of blocked area (\*\*) on Fig. 5(b). Lymphatics (arrows) passing with blood vessels along the phrenic nerve. A=phrenic nerve; bv=blood vessel.

#### ACKNOWLEDGMENTS

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Fig. 8. A cleared specimen showing a lymphatic network of the parietal pericardium in the dog.

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