

## Lymphatics of the Canine Papillary Muscles

H.N. Uhley, S.E. Leeds

Departments of Medicine, and Experimental Surgery Laboratory, Mount Zion Hospital and Medical Center, San Francisco, California, U.S.A.

Supported by the National Institutes of Health Grant No. HL 03180-19

### Summary

A relatively dense concentration of lymphatics in the region of the papillary muscles of the canine left ventricle has been described. It is suggested that these channels may play a role in the development of pathologic changes affecting the mitral valve apparatus which could subsequently cause valve dysfunction.

### Introduction

Within recent years new knowledge of the canine cardiac lymphatic system has been important in elucidating various physiologic and pathologic states (1-12). In the course of studies on the subendocardial lymphatics of the canine heart (13) we noted an intense concentration of lymphatics in the region of the papillary muscles. This observation led to further studies which form the basis of this report.

### Methods

Fifteen dogs were used in this study. The heart was removed and washed free of blood. Evans blue dye or Pelican India ink was injected subendocardially with a No. 30 needle and the distribution of the fine lymphatics emanating from the injection site was observed and photographed with a Zeiss operating microscope and camera. Injections were principally made in the left anterior and posterior papillary muscles.

### Results

These studies demonstrate that the anatomic arrangement as well as the size of the canine subendocardial lymphatics varies. The lymphatics appear to group as fine or coarse structures; the former are much more difficult to demonstrate and seem to be localized more superficially. They present as a delicate reticular network on the papillary muscle (Fig. 1). On the other hand, the coarse lymphatics are easier to demonstrate and appear as linear vessels or interconnected networks. The interconnected networks are most characteristically seen on the surface of the anterior and posterior papillary muscles of the left ventricle and are especially prominent at the summits of the left ventricular anterior and posterior muscles (Fig. 2). The connective tissue that forms the base of the chordae tendinae is rich in coarse tortuous lymphatics that are extensively intermeshed (Fig. 3). Some of the lymphatic vessels reach out along chordae

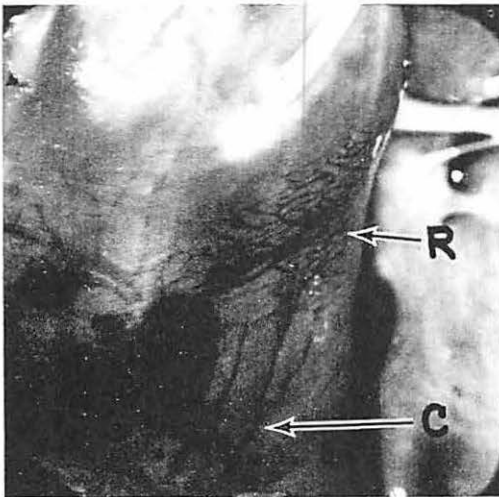


Fig. 1 The types of lymphatics visualized vary in arrangement and size. Note the fine reticular network (R), and the coarser linear vessels (C) on the left anterior papillary muscles.



Fig. 2 Prominent densely concentrated lymphatics on a papillary muscle summit. The dense coarse interconnected network gives the appearance of a "bag of worms".



Fig. 3 The connective tissue on the top of the papillary muscle that forms the base of the chordae tendinae is rich in coarse tortuous lymphatics.

tendinae from the papillary muscle and progress in a linear fashion (Fig. 4). The intermeshed, highly concentrated lymphatics on the left ventricular papillary muscles contrast sharply with the less abundant and more linear lymphatics on the remaining left ventricle endocardium.

#### Discussion

This study demonstrates the presence of a rich lymphatic network, concentrated in the regions of the papillary muscles of the canine heart. The network is especially prominent near the summits of the left ventricular papillary muscles, particularly in the region of connective tissue which ultimately forms the chordae tendinae.

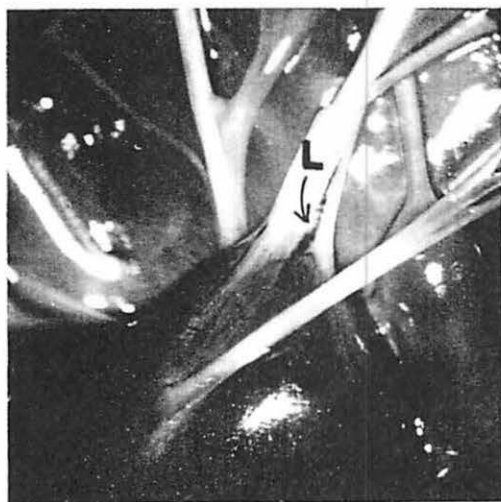


Fig. 4 A linear lymphatic (L) along the chordae tendinae.

It is of interest to know why the concentration of lymphatics should be particularly high in this area. One possibility is that in the period of maximal ejection, the egress of lymph flow may be impeded by contraction of the papillary muscle. This would tend to increase intralymphatic pressure and enhance dilation and expansion of these vessels in the non-contractile connective tissue at the summits of the papillary muscles.

The papillary muscle is part of the mitral valve apparatus which consists of the various components: the mitral annulus, papillary muscles, chordae tendinae, and valve leaflets. Accordingly, mitral valve dysfunction may stem from disturbance of any of the component parts of mitral valve apparatus (14).

Permission granted for single print for individual use.

Reproduction not permitted without permission of Journal LYMPHOLOGY.

Fibrotic scarring is the pathologic finding frequently associated with papillary muscle damage (15). However, not all fibrosis is related to occlusive coronary disease (16). In some instances the formation of fibrotic tissue might be influenced by the lymph system. If the lymph channels are interfered with and flow is altered, particularly in critical locations such as the chordae tendinae, adequate drainage and resolution of an area of inflammation may be inhibited. This could lead to the local development of fibrosis and possibly affect various components of the mitral valve apparatus. Fibrosis of portions of these structures might result in the subsequent occurrence of valvular dysfunction.

#### Acknowledgement

The authors wish to acknowledge the technical assistance of Richard Meister and Victor Villaluna.

#### References

- 1 Patek, P.E.: The morphology of the lymphatics of the mammalian heart. *Am. J. Anat.* 64 (1939) 203-249
- 2 Müller, A.J., R. Pick, L.N. Katz: Ventricular endomyocardial pathology produced by chronic cardiac lymphatic obstruction in the dog. *Circ. Res.* 8 (1960) 941-947
- 3 Kline, I.: Lymphatic pathways in the heart. *Arch. Path.* 88 (1969) 638-644
- 4 Areskog, N.H., G. Arthurson, G. Grotte: Heart lymph: electrolyte compounds and changes induced by cardiac glycosides. *Biochem. Pharmacol.* 14 (1965) 783-787
- 5 Rossi, L.: Case of cardiac lymphangitis with atrioventricular block. *Brit. Med. J.* 2 (1965) 32-33
- 6 Symbas, P.N., T. Cooper, G.E. Gantner Jr., et al: Lymphatics of the heart. *Arch. Path.* 81 (1966) 573-579
- 7 Johnson, R.A., M.M. Blake: Lymphatics of the heart. *Circulation* 33 (1966) 137-142
- 8 Ruzsnyak, I., M. Földi, G. Szabo: Lymphatics and Lymph Circulation. Pergamon Press, New York 1960
- 9 Uhley, H.N., S.E. Leeds, J.J. Sampson et al.: The cardiac lymphatics in experimental chronic congestive failure. *Proc. Soc. Exp. Biol. Med.* 131 (1969) 379-381
- 10 Yoffey, J., F. Courtice: Lymphatics, lymph and lymphomyeloid complex. Academic press New York 1970
- 11 Leeds, S.E., H.N. Uhley, J.J. Sampson et al.: The cardiac lymphatics after ligation of the coronary sinus. *Proc. Soc. Exp. Biol. Med.* 135 (1970) 59-62
- 12 Uhley, H.N., S.E. Leeds, F.R. Elevelitch: Canine cardiac lymph and pH after experimental myocardial infarction. *Proc. Soc. Exp. Biol. Med.* 151 (1976) 146-148
- 13 Uhley, H.N., S.E. Leeds, M.A. Sung: The subendocardial lymphatics of the canine heart. *Am. J. Cardiol.* 29 (1972) 367-376
- 14 Burch, G.E., N.P. Depasquale, J.H. Phillips: Clinical manifestations of papillary muscle dysfunction. *Arch. Int. Med.* 112 (1963) 112-117
- 15 DeBusk, R.F., D.C. Harrison: The clinical spectrum of papillary muscle disease. *New Engl. J. Med.* 281 (1969) 1458-1467
- 16 Brand, F.R., A.L. Brown, Jr., K.G. Berge: Histology of papillary muscles of the left ventricle in myocardial infarction. *Am. Heart J.* 77 (1969) 26-32

Herman N. Uhley, M.D., Mount Zion Hospital and Medical Center, P.O. Box 7921, San Francisco, California 94120, U.S.A.