Lymphology 5 (1972) 161-169

Studies on the Lymph Node-Venous Communications

III. The Presence of Saccular Sinuses and their Possible Function*

R.F. Dunn, R.W. Strahan

Department of Surgery, Division of Head and Neck Surgery (Otolaryngology), UCLA School of Medicine, Los Angeles, California (USA)

Summary

From analysis of serial sections of the canine medial retropharyngeal lymph node, sinuses with a saccular configuration have been delineated. Maximum dimensions of the saccular sinus analyzed varied from 13-25 μ through the depth of the serial sections, a distance of approximately 0.5 mm. The saccular sinus opened at either end into a normal, irregularly-shaped sinus. Continuity was observed between a distinctly separate tubular vessel and the saccular sinus. The vessel appears to arise obliquely from the saccular sinus and is first seen as an evagination, approximately 100 μ in length, of the endothelial border of the saccular sinus. At the region of continuity, the vessel was approximately 10 μ in diameter and increased to approximately 25 μ in diameter where fully separated from the saccular sinus. Approximately 20 μ from the region of vessel-saccular sinus continuity, endothelial strands projected across the vessel lumen. Reconstructions of approximately 36 μ of this area disclosed that these strands were tricuspid and arch-shaped in structure and could function as a valve. These structures are discussed in relationship to the direct lymph node-venous transfer of tracer substances.

When the lymphatic duct becomes obstructed as a result of either induced or pathological obstacles, functional extranodal lymphaticovenous communications appear to act as a bypass mechanism (1-8). Experimental evidence has demonstrated the presence of lymph node-venous communications, has shown that short-term, rapid passage of tracer substances and cells may be pressure related, and has suggested that certain anatomical structures may serve as a mixing chamber with two possible exits (9, 10). Histological evidence is presented herein to document the presence of a system of anatomical structures which may serve as the morphological pathway for intranodal pressure-related transfer from lymph node sinuses directly to the venous system.

Methods and Materials

Either the left or right medial retropharyngeal lymph node was removed from each of 4 dogs and utilized as in previous experiments (9, 10). The nodes were freed, immediately sliced, and fixed in cold 2.5% glutaraldehyde in isotonic phosphate buffer for 1 to 2 hours. After a buffer rinse, portions of the tissue were trimmed to 3 mm cubes and post-fixed in cold isotonic phosphate-buffered 2% osmium tetroxide for 2 to 3 hours. The tissue subsequently was embedded in Epon-812 as previously described (11). The blocks were sectioned at 1.5 μ with a Porter-Blum MT-2 microtome with glass knives. Sections were stained with aqueous toluidine blue, and the photomicrographs were taken with a Zeiss Ultraphot equipped with phase optics. A magnification of either x200 or x500 was used for the original photomicrographs, and the final prints were adjusted photographically to the same magnification.

---

*This work was supported by Public Health Service Research Grant No. CA-10923 from the National Cancer Institute.

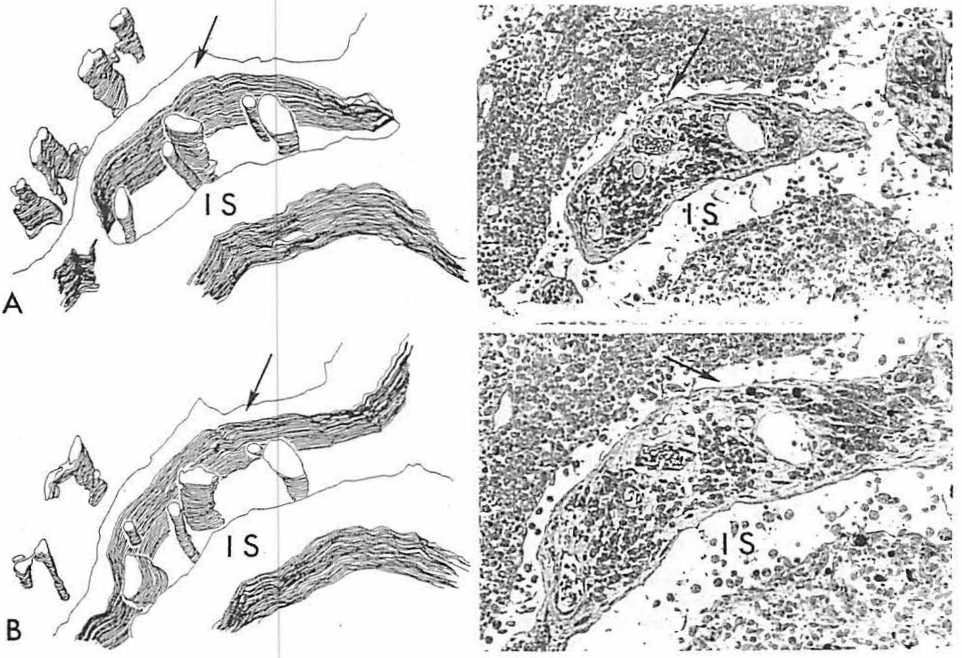

Fig. 1A

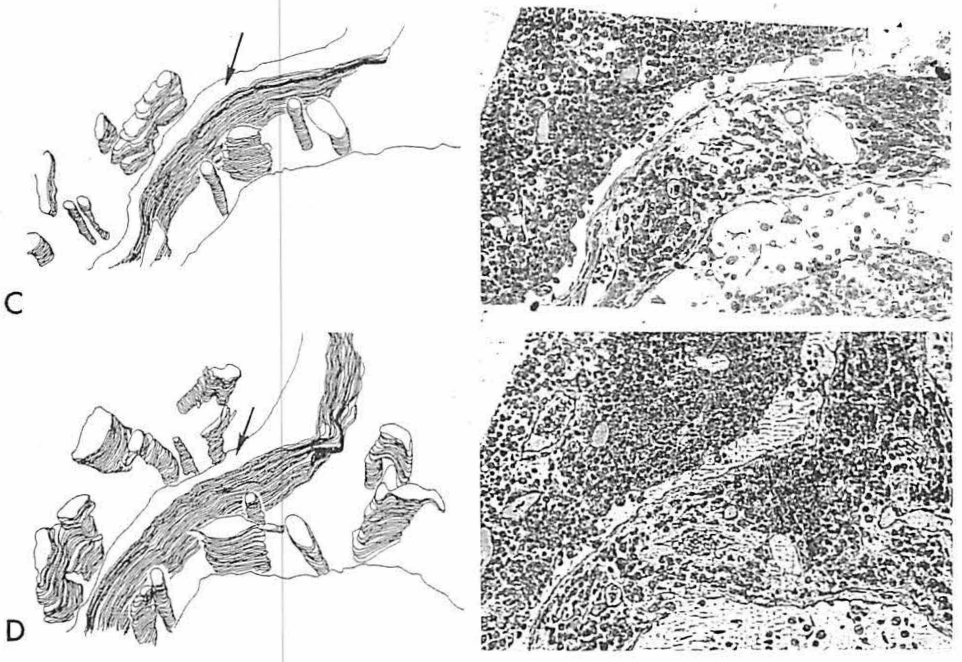

Fig. 1B

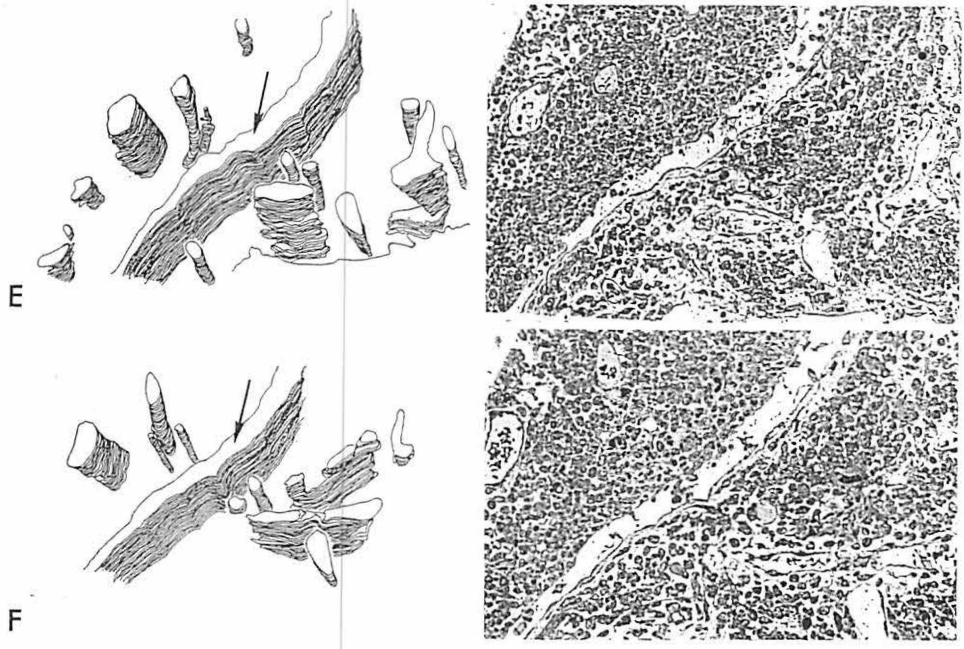

Fig. 1E-F

Analysis of one saccular sinus was completed from a series of 326 sections covering a depth of approximately 0.5 mm. The graphic representations were constructed from segments consisting of approximately 30 sections each and are presented adjacent to the micrograph of the top section from that segment. Sequential illustrations were prepared so that the top of each segment was continuous with the bottom of the preceding segment. Schematics were made by outlining only the lumens of the saccular sinus, a portion of the irregular sinus, and the blood vessels in each section, producing a representation of the surface contours as viewed from one side and thus depicting luminal progressions through the tissue block. Detailed preparation of the graphic three-dimensional representations has been previously described (12).

Results

Sinus Saccular Configuration

Although sinuses of the medial retropharyngeal lymph nodes generally are large, quite irregular in shape, and highly branched, some are regular in shape with a saccular configuration. Easily misinterpreted as vessels in single sections, this saccular configuration was readily seen by analysis of the serial sections. The maximum dimension across the lumen of the saccular sinus varied from 13-25 μ through the depth of the tissue.

The lumen of the saccular sinus was lined with attenuated endothelial cells and occasional fixed macrophages. The saccular sinus opened at either end to a normal irregular sinus (Fig. 1A). The trabecular "island" forming one side of the saccular sinus contained three venules and two arterioles, as well as numerous fibrocytes, unclassified

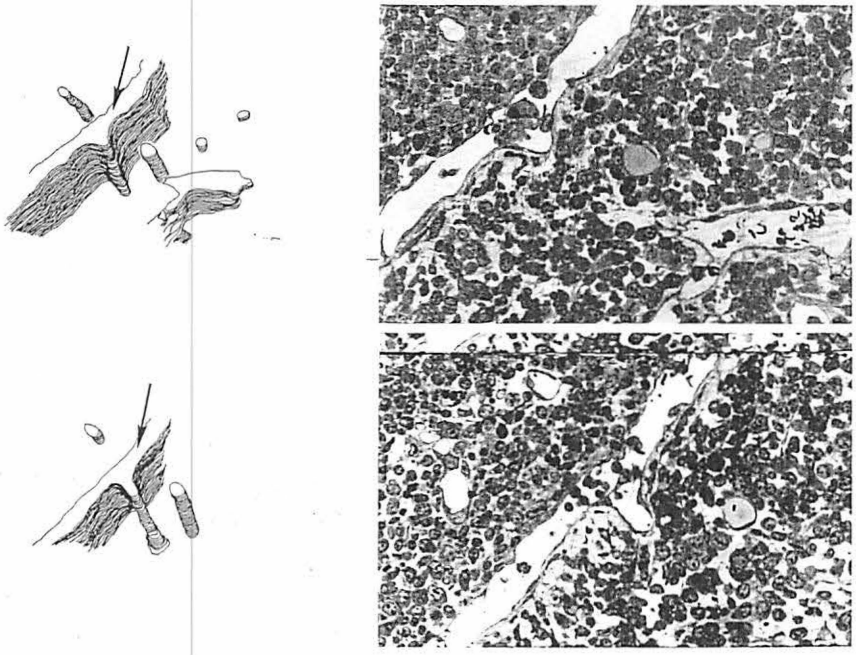

Fig. 1G-H

Fig. 1. Schematic representations of the lumens of a saccular sinus (arrows) and a portion of an irregular sinus (IS). The unlabeled profiles are of various blood vessels included within the sections. Each schematic represents a segment of approximately 30 sections. The adjacent photomicrograph is of the top section of that segment. The segments are arranged sequentially so that the bottom of A is a continuation of the top of B, the bottom of B is a continuation of the top of C, and so forth. The schematics are presented to illustrate the saccular configuration of a lymph node sinus as it progresses through the depth of the tissue. Although the sinus luminal surfaces show moderate undulations, the saccular shape is retained. The graphic segments are reproduced at the same magnifications. The respective magnification of the photomicrographs are: A. x138; B. x166; C. x166; D x152; E. x166; F. x207; G. x310; H. x310.

lymph node cells, and collagen bundles. The opposite side of the saccular sinus was bordered by the coronal portion of a germinal center and contained several blood vessels within a preponderance of loosely packed lymph node cells.

The dimensions of the saccular sinus gradually decreased to approximately 10-15 μ in width through a depth of 216 μ (Fig. 1B, C, D). At mid-level, the saccular sinus was bordered on both sides by an area of loosely packed lymph node cells in which several venules and arterioles were present (Fig. 1E). At this level, the luminal dimensions ranged in width from 8-13 μ along the remaining depth of the serial sections analyzed (Fig. 1E-H). The overall configuration of the saccular sinus appeared to be an extension or, possibly, a cul-de-sac arising from an irregular sinus.

The schematic representations demonstrate graphically the steep appearance and moderate undulations of the saccular sinus, characteristics not readily discernible in single sections. These characteristics were consistent with measurements on the light micrographs. Both sides of the saccular sinus showed similar contours. When followed

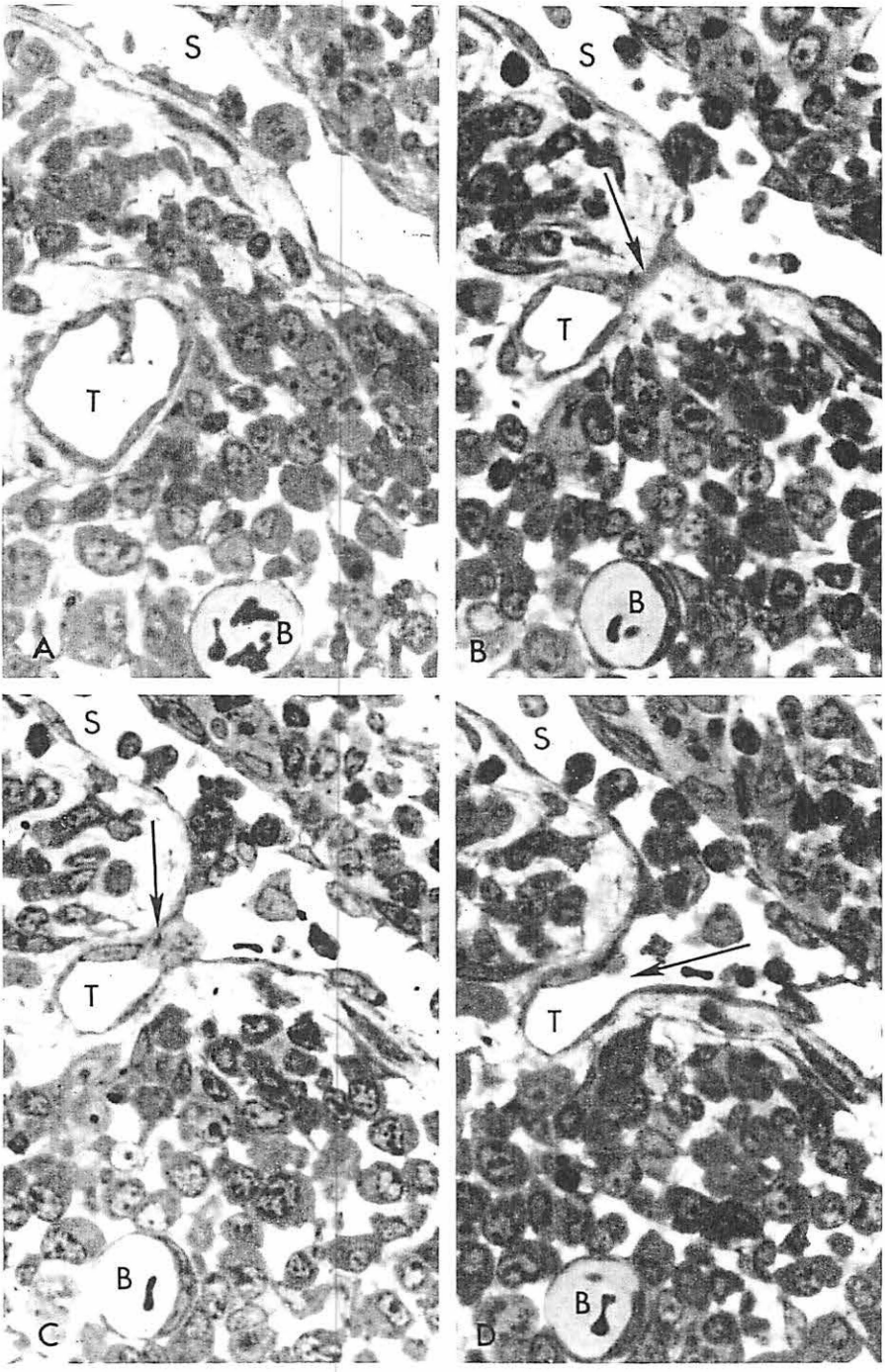

Fig. 2. Four nonconsecutive sections illustrate the continuity of the lumen of the tubular vessel with that of the saccular sinus. A. A portion of the saccular sinus (S) is shown bordered by at-

tenuated endothelial cells. A tubular vessel (T) is separated from the sinus. A small blood vessel (B) is partially filled with erythrocytes and is included as a structure of reference. x900.
B. A section approximately 20 μ away from that shown in A. The diameter of the tubular vessel (T) has decreased, and its position has shifted towards the saccular sinus (S). A portion of the vessel's endothelium appears continuous to that of the sinus (arrow). x900.
C. A section approximately 8 μ away from that shown in B. The endothelium of the tubular vessel (T) is continuous with that of the saccular sinus (S), and the continuity appears to be occluded by a cell (arrow). x900.
D. A section approximately 3 μ away from that shown in C. The continuity between the saccular sinus (S) and the tubular vessel (T) is clearly delineated (arrow). x900.

through the schematic segments, a gradual decrease, from 20-25 to 8-13 μ, in the width dimension of the saccular sinus was evident from the level of Figure 1A to the level of Figure 1H.

Sinus-Vessel Communication

The continuity noted between the saccular sinus and a separate tubular vessel was striking (Fig. 2A-D). The vessel, sectioned tangentially, appeared irregularly elliptical in contour. The diameter of the vessel was approximately 25 μ and gradually decreased to approximately 10 μ as the region of continuity was approached. Past the continuity, a portion of the vessel wall continued for about 100 μ as a discernible "gutter" or outpocketing of the saccular sinus (Fig. 3). The lumen of this vessel was lined with 3-5 attenuated endothelial cells continuous with the endothelial cells of the saccular sinus at the region of continuity.

Endothelial Valve-Like Structure

Inspection of the vessel lumen suggested the presence of a valvular structure (Fig. 2A, B). Partial reconstructions from this region of the tubular vessel were performed according to the technique of *Bang and Bang* (13). The reconstructions revealed an arch-formed structure that extended from the endothelial lining and projected across the lumen of the vessel through a depth of approximately 36 μ (Fig. 4). The valve-like structure was continuous with the endothelial lining at three points and unattached to any other luminal surface, presenting a tricuspid appearance (Fig. 4). The broad region of primary attachment contained an elliptical cell nucleus approximately 4 μ across the minor axis. A small branch emanated laterally from the primary process toward the adjacent vessel wall, thus creating a short secondary lumen (Fig. 4). As the primary process continued downward, it became attenuated and unattached to the vessel wall for approximately 6-8 μ before reattaching to the vessel wall on the side opposite.

Discussion

When radioactive iodinated serum albumen (RISA) is injected into the lymph node via one afferent lymphatic channel at elevated pressures, a close correlation occurs between the rapid rise and subsequent sharp decline in radioactivity recovered from the adjacent internal jugular vein. The model previously proposed to account for passage across the lymph node-venous communication was based upon this concept (9). In view of the anatomical observations presented here, the model suggests a mixing chamber (a saccular sinus) with a single entrance (an afferent lymphatic) and two possible exits, one

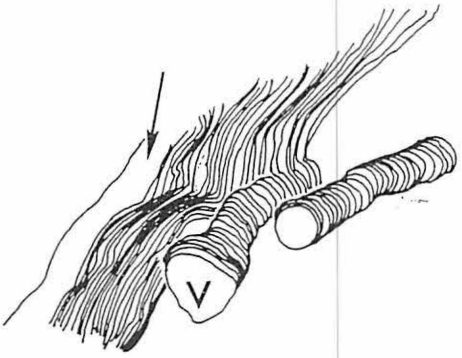

Fig. 3. Schematic representation of the region of sinus-vessel continuity. The saccular sinus (arrow) is clearly separated from the vessel (V). The vessel approaches the saccular sinus obliquely, connects, and then continues as an evagination of the sinus lumen.

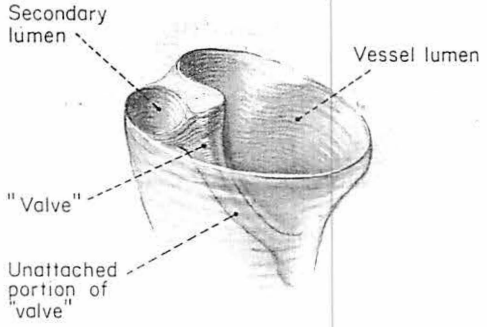

Fig. 4. Schematic drawing of the valve-like structure within the vessel communicating with the saccular sinus. The primary process (at top of drawing) has a broad attachment to the luminal endothelium. A lateral branch creates a short secondary lumen. The primary process at this site is free from the vessel wall but later becomes reattached on the opposite side.

of which contains a valve-like structure and one which does not (a venule and the efferent lymphatic, respectively). When pressure within the mixing chamber is higher than that of the venous system, exit would occur through both the valved and patent openings. Conversely, when pressure within the mixing chamber is lower than that of the venous system, exit would be allowed only through the patent channel.

The finding that Cr^{51} labeled exogenous erythrocytes (10) and HeLa cells (14) also passed through this lymph node-venous communication indicates that the pathway must be at least the size of a capillary. The short time span and the apparent pressure dependency observed in the tracer experiments probably preclude passage via an endothelial transference mechanism. The same short time period, together with occlusion of the efferent channel and the adjacent internal jugular vein distal to the node past the sampling site, would preclude passage through the general circulation. Although no absolute figures are available as to the number of saccular sinuses present in a node, they are encountered only infrequently and appear to contain only a single sinus-vessel opening. This may account in part for the low percentages of tracer recovered from the adjacent internal jugular vein in previous experiments (9, 10).

Three-dimensional analysis through a depth of approximately 0.5 mm is sufficient to establish that the structure followed is not a blood vessel and that it is a sinus of saccular configuration. Once the three-dimensional configuration was established by extensive reconstruction, saccular sinuses were easily recognized in single sections.

The observation that the saccular sinus is one limb of an irregular sinus necessitates that the tracer be present within the lumen before any transfer could occur. When colloidal carbon particles are used (injected into the lymph node via the afferent lymphatic), the tracer has been observed with the electron microscope within the saccular sinuses (15). Although thin sectioning techniques prevent following these sinuses for extended distances, the presence of the tracer within the saccular sinuses corroborates their continuity with the irregular sinuses and indicates no effective impediment between the two.

The "valve" arrangement within the vessel that communicates with the saccular sinus was not traced in its entirety and doubt remains as to whether it can occlude completely the entrance of tracers into the vessels. A competent valvular arrangement is suggested by observations from experiments in which colloidal carbon particles were injected retrograde through the vein that joins the lymph node and the adjacent internal jugular vein. The carbon particles were limited to the capillaries, and none was found in any of the sinuses (15).

The findings of a saccular sinus and its observed continuity are consistent with the concept that the saccular sinus may function as a mixing chamber.

Acknowledgement

The authors wish to express their appreciation to Mrs. *Margot Brundage* for her expert technical assistance in preparation of the sections and schematics.

References

1 *Threefoot, S.A., W.T. Kent, B.F. Hatchett:* Lymphaticovenous and lymphaticolymphatic communications demonstrated by plastic corrosion models of rats and by post-mortem lymphangiography. J.Lab.Clin.Med. 61 (1963) 9-22

2 *Threefoot, S.A., M.F. Kossover:* Lymphaticovenous communications in man. Arch. Int.Med. 117 (1966) 213-233

3 *Sterns, E.E., G.E.R. Vaughn:* The lymphatics of the dog colon. Cancer 26 (1970) 218-231

4 *Bron, K.M., S. Baum, H.L. Abrams:* Oil embolism in lymphangiography. Radiology 80 (1963) 194-202

5 *Carlsten, A., T. Olin:* The route of the intestinal lymph to the blood stream. Acta Physiol.Scand. 25 (1952) 259-266

6 *Larson, D.L., T.P. Bond, A.E. Rodin et al.:* Clinical and experimental obstruction of the thoracic duct. Surgery 60 (1966) 35-42

7 *Takashima, T., D.L. Benninghoff:* Lymphatico-venous communications and lymph reflux after thoracic duct obstruction. Investig.Radiol. 1 (1966) 188-197

8 *Roxin, T., H. Bujar:* Lymphographic visualization of lymphaticovenous communications and their significance in malignant hemolymphopathies. Lymphol. 3 (1970) 127-135

9 *Dunn, R.F., M.V. Burtz, P.H. Ward:* Studies on the lymph node-venous communication. I. The passage of radioactive serum albumen. Lymphol. 3 (1972) 17-25

10 *Dunn, R.F., M.V. Burtz, P.H. Ward:* Studies on the lymph node-venous communication. II. The passage of labeled exogenous erythrocytes. Lymphol. 5 (1972) 120-127

11 *Pressman, J.J., R.F. Dunn, M.V. Burtz:* Lymph node ultrastructure related to direct lymphaticovenous communication. Surg. Gynec.Obstet. 124 (1967) 963-973

12 *Dunn, R.F.:* Graphic three-dimensional representations from serial sections. J.Microsc. (in press)

13 *Bang, B.G., F.B. Bang:* Graphic reconstructions of the third dimension from serial electron micrographs. J.Ultrastruct.Res. 1 (1957) 138-146

14 *Pressman, J.J., R.F. Dunn, M.V. Burtz:* Direct communications between lymph nodes and veins. In: Progress in Lymphology. II, M. Viamonte, P.R. Koehler, M. Witte, C. Witte (eds.). Georg Thieme Verlag, Stuttgart 1970, pp. 77-78

15 *Dunn, R.F.;* Ultrastructural evidence for the lymph node-venous transport of carbon particles. In preparation.

R.F. Dunn, R.W. Strahan, Department of Surgery, Rehab 31-19, UCLA School of Medicine, Los Angeles, California 90024 (USA)

Lymphology 5 (1972) 169-170

ABSTRACTS

Lymphoceles Following Renal Transplantation

R.T. Schweizer, S. Cho, S.L. Kountz, F.O. Belzer
Dept. of Surgery, University of California, San Francisco, San Francisco, California 941 22
Arch.Surg. 104 (1972) 42-45

The records of 280 patients with renal transplantations performed at the University of California (San Francisco) were reviewed. Nine deep lymphoceles developed in six patients, an incidence of 2%. The primary symptom was a decrease in renal function; two presented with symptoms of "pressure sensation" in the pelvis and groin; some gained weight and showed symptoms of fluid retention. Ipsilateral leg swelling was common. A lymphocele was palpated in only one patient.

Diagnosis was usually made by intravenous pyelography in which progressive displacement of the urinary bladder towards the side opposite to the transplant was detected.

In three patients the lymphocele was not initially appreciated; patients had been given increased doses of immunosuppressive drugs because the decreased renal function was interpreted as threatened rejection. In this series all lymphoceles were surgically drained. The volumes ranged from 340-1200 ml. In two patients the fluid when analyzed, in protein levels was 1.6 gram/100 ml and 2.1 gram/100 ml. Electrolytes and urea nitrogen values were similar to serum. The drains were removed on the fifth post-operative day. Renal function promptly improved and the symptom disappeared in all patients following drainage. All lymphoceles were initially sterile and a significant infection developed only in one. This was the only serious complication in this series. *P.R. Koehler*

Lymphatic Visualization During Contrast Arthrography of the Knee

J.R. Lewin, L.M. Mulhern
Div. of Diag.Rad., Dept. of Rad. (J.R.L.) and Div. of Rheumat., Dept. of Med. (L.M.M.) Mercy Hosp. and Health Center, Pittsburgh, Pennsylvania
Radiology 103 no. 3 (1972) 577-579

The authors performed contrast arthrography of the knee in patients with chronic rheumatoid disease. In several instances, they observed radiographic opacification of lymphatic channels about the knee joint. On the other hand, in 650 patients in whom arthrograms were done mainly in the search of meniscus injuries, no opacification of lymph vessels was noted. It is felt that the changes in permeability of the synovial