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Intrinsic Contractility of Leg Lymphatics in Man Preliminary Communication

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Summary

Intralymphatic pressures were measured in subcutaneous trunks of 5 randomly selected healthy individuals. Rhythmic pulse waves of different frequency, amplitude of 1–33 mmHg, duration of 6–8 sec and steadily increasing mean pressure up to 50–120 mmHg were found, with subjects in the upright position and motionless. Coincidence of the rhythm of pulse waves with the rhythm of expression of drops of lymph from the cannula strongly suggests that pressures necessary to propel lymph were generated by the contractility of lymph vessel wall.

Introduction

In man, the mechanism(s) responsible for propulsion of lymph is still rudimentary. Knowledge is based largely on observations in experimental animals where muscular activity and respiration significantly enhance lymph flow. However, the question remains, what factor propels lymph in man at rest when the squeezing effect of muscular contraction is absent.

In this preliminary communication we describe a lymphatic "pulse" in leg lymphatics of healthy men. The findings suggest that spontaneous intrinsic rhythmic contractions of lymph vessels may be a major determinant of lymph flow.

Material and Methods

Studies were performed in 5 randomly selected male volunteers aged 19–22. Leg subcutaneous lymph vessel was cannulated against the direction of lymph flow, according to the techniques described previously (1, 2), with the exception that no dye was injected into the skin of the dorsum of the foot for visualizing of lymphatics. The approximate diameter for the cannulated lymphatics ranged between 0.1 and 0.3 mm. A polyethylene P60 Adams Clay cannula, with the tip adjusted in each case to the diameter of the vessel, was inserted into the lumen. The vessel was tied with a 6–0 silk thread over the inserted part of the cannula. The volunteers were then allowed to perform their normal daily activities. Studies were performed on day 4 and 5 after the cannulation when the operative wound has already been partially healed. Lymph was collected continuously into calibrated containers and flow in $ml.hr^{-1}$ calculated. For pressure measurement the external end of cannula was connected with a pressure transducer AE 840 (Solid State Products) and the amplified signals were recorded by means of a direct-writing Beckman R 611 Dynograph recorder. Pressure determinations were standardized to a zero baseline at the level of the internal opening of the cannula. Lymphatic pressures were measured in the subjects in an upright position avoiding any movements. Only end pressures were recorded as the proximal parts of lymphatics had not been cannulated. Observations obtained from all 5 volunteers will be presented briefly.

No. 1 (cannulation 282). After closing the stopcock equilibrating the pressure within the cannula with the atmosphere, a sudden increase in pressure up to 2 mmHg and after 40 sec interval to 9 mmHg were recorded. Then, after a 95 sec lasting period of stable pressure a rise

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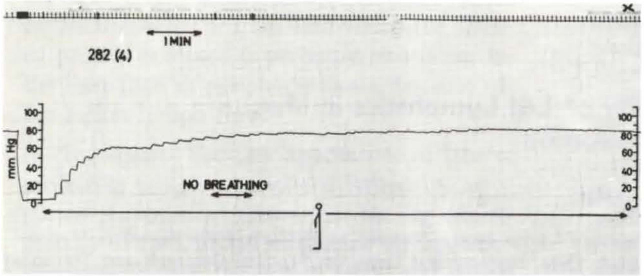

Fig. 1 Intralymphatic pressure pattern in case No. 1
For details see text

to 16 mmHg was noted. At that level rhythmic pulsations appeared composed of several groups of waves seen at intervals of 30 to 40 sec. The amplitude of pulse waves was 4–6 mmHg. Each wave lasted for 6 sec. The mean end pressure reached in 5 min 50 mmHg. After 30 min in an upright position the recording system was opened for 1 min to equilibrate with the atmospheric pressure, then recording resumed. A series of pulse waves with the amplitude of 3 to 15 mmHg, each pulse wave of 6 sec duration, was observed (Fig. 1). The mean pressure reached in about 1 min 60 mmHg. There was a 40 sec lasting relaxation period after which another series of pulsations was observed, lasting for 2.5 min. Then, groups of low amplitude waves could be seen at intervals of 40 sec. With the increase of the mean pressure the amplitude of pulse waves decreased. The mean lymph pressure reached the highest value of 90 mmHg. The lymph flow rate was 0.37 $ml.hr^{-1}$, what remained within the medium range of normal values for men of this age group (3).

No. 2 (cannulation 284). The end pressure in the cannulated lymphatic rose in 5 sec abruptly to 4 mmHg, then at 20 sec intervals to 16 and 25 mmHg (Fig. 2). This was followed by a series of pulse waves of the amplitude of 2–5 mmHg and duration of each wave for 6 sec. The mean pressure reached in 4 min 60 mmHg. and remained at that level for a period of 15 min. Muscular movements of the calf and respiration did not affect the intralmyphatic pressure pattern. The lymph flow rate was 0.06 $ml.hr^{-1}$, what was much below the normal means.

No. 3. (cannulation 287). The lymph pressure rose after 30 sec abruptly to 8 mmHg, then in 20 sec to 17 mmHg and after 10 mor sec to 25 mmHg. At that level pulse waves appeared in series of 4–9, each wave of 6 sec duration (Fig. 3). The mean pressure rose during each series of pulsewaves to decrease slightly during the pulseless period. In a 10 min period pressure rose by 8 mmHg to reach eventually the level of 48 mmHg. No further increment in pressure was observed. The flow rate was 0.14 $ml.hr^{-1}$..

No. 4 (cannulation 288). The lymph pressure pattern was similar to that of the previous subject.

No. 5 (cannulation 291). After closing the

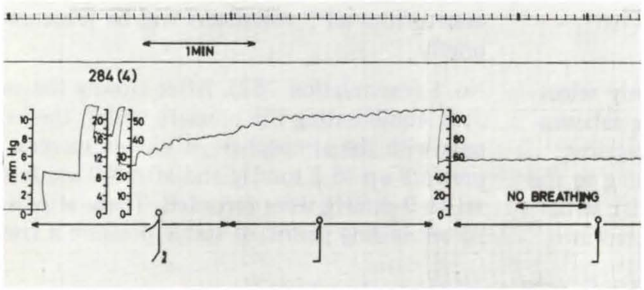

Fig. 2 Intralymphatic pressure pattern in case No. 2
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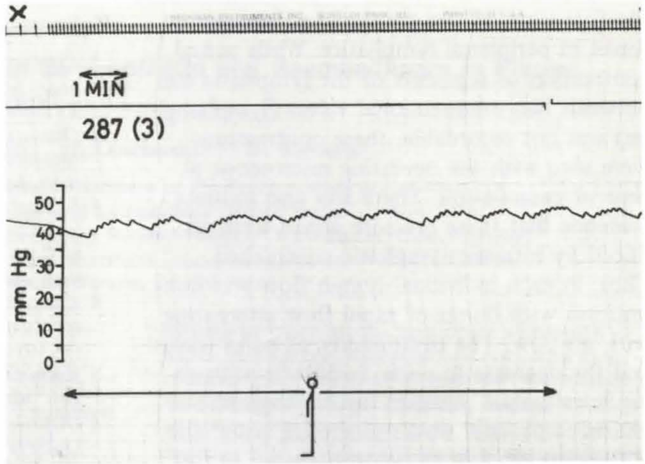

Fig. 3 Intralymphatic pressure pattern in case No. 3. For For details see text

stopcock equilibrating the recording system with the atmospheric pressure 3 pulse waves appeared already in 5 sec, with the amplitude of 18, 20 and 25 mmHg respectively, followed by two lower waves and a 30 sec lasting period of steady state at the level of 30 mmHg (Fig.4). After a 15 sec period of decreasing pressure two pulse waves appeared with the amplitude of 30 and 16 mmHg. There was a 25 sec interval of nonpulsatile pressure at the level of 40 mmHg. Two more 33 and 16 mmHg high pulse waves could then be seen proceeded by continuous pulsation composed of waves of the amplitude of 3–5 mmHg. Mean end pressure reached 50 mmHg in 4 min and 100 mmHg in 15 min. The increase in lymph pressure seemed to dampen out the pulse wave amplitudes. The highest recorded end pressure was 120 mmHg. The duration of pulse waves ranged between 7 and 8 sec. The lymph flow rate was high, 0.8 $ml.hr^{-1}$ and the rhythm of pressure peaks seen on recording charts was the same as of expression of drops of lymph from the end of the cannula.

Discussion

In animals, intrinsic contractions of lymphatics have been observed in wings of bats (8), in lacteals of birds, horses, dogs (9), guinea pigs (10–13), rats (11–13), on the pleural surface of the diaphragm in guinea pig (11), limbs and testes in the rat and guinea pig (14), liver and bowel of the rat, lumbar region, extremities, ovary, mammary gland, intestine, liver, neck and thoracic duct of sheep (15), and mesentery of cattle (16, 17). Rhythmic contractions of the thoracic duct in patients have also been described by Kinmonth and Taylor (4), and Kinmonth (5) and Olszewski (6) have reported contractility of retroperitoneal lymphatics where rhythmic waves of lymph flow were observed during cinelymphangiography and directly at operation. In 1963 Szegvari (7) published 2 photographs of a contracted and relaxed peripheral lymphatic in a patient undergoing diagnostic lymphangiography. However, no lymph flow or pressure measurements were recorded.

To our knowledge, our study establishes for

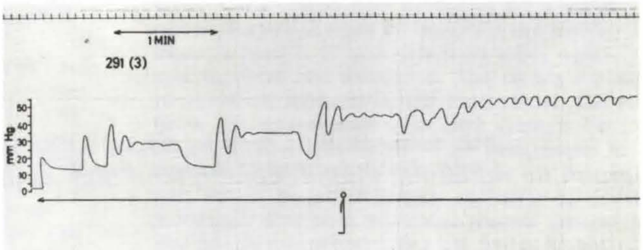

Fig. 4 Intralymphatic pressure pattern in case No. 5. For details see text

the first time in man rhythmic pulse-pressure waves in peripheral lymphatics. While actual contraction of segments of the lymphatic wall between two unidirectional valves (lymphangion) was not recordable, these contractions were seen with the operating microscope at time of cannulation. There was also indirect evidence that these pressure waves were produced by intrinsic lymphatic contraction. Thus, in each individual lymph flow was nonuniform with bursts of rapid flow alternating with no flow. The rhythmicity of pulse waves and the decrease in pulse amplitude with rising intraluminal pressure further suggested intrinsic contractile waves of the leg lymphatic. While considerable variation occurred in frequency and amplitude of pulsation from individual to individual, the duration of pulse waves in each was similar. Pulse waves were asynchronous with respiration or movement of the leg and the pressure transmitted by muscle contraction accounted for only 1–2% of the pulse amplitude. Finally, the subject with the highest lymph flow (No. 5) also had the highest pulse pressure.

While these volunteers remained stationary during recording in an upright position, we have observed similar responses in supine individuals. Thus, waves of lymphatic pulse generating intralymphatic pressure of 50 mmHg have been seen with the leg held in a horizontal position despite low capillary filtration rate and minimal lymph flow. These findings suggest that intrinsic lymphatic contractility in man is not only a potent force in lymph propulsion, but when deranged may be a major factor in disorder characterized by lymphatic dysfunction.

References

1 *Engeset, A., B. Hager, A. Nesheim, A. Kolbenstvedt:* Studies on human peripheral lymph I. Lymphology 6 (1973) 1

2 *Olszewski, W.L.:* Collection and physiological measurements of lymph and interstitial fluid in man. Lymphology 10 (1977) 137

3 *Engeset, A., W.L. Olszewski, P.M. Jaeger, J. Sokolowski, L. Theodorsen:* Twenty-four hour variation in flow and composition of leg lymph in normal man. Acta physiol. scand. 99 (1976) 140

4 *Kinmonth, J.B., G.W. Taylor:* Spontaneous movements of lymph vessels. J. Physiol. (Lond.) 133 (1956) 3P

5 *Kinmonth, J.B., G.W. Taylor:* Chylous reflux. Brit. med. J. I (1964) 528

6 *Olszewski, W.L., St. Kruszewski, L. Zglicynski:* Observations of movements of lymph vessels in patients with lymphedema of limbs. Pol. Tyg. Lek. 23 (1968) 1345

7 *Szegvari, M., Lakos, A., F. Szontagh, M. Foldi:* Spontaneous contractility of lymph vessels in man (letter to Editor). Lancet 1963/I, 1329

8 *Nicoll, P.A., R.D. Hogan:* Pressure associated with lymphatic capillary contractility. Microvasc. Res. 15 (1978) 257

9 *Hewson, W.:* In the works of William Hewson, ed. G. Gulliver. Sydenham Soc. 1774. London

10 *Heller, A.:* Über selbständige rhythmische Kontraktionen der Lymphgefäße bei Säugetieren. Z. Med. Wiss. 7 (1869) 545

11 *Florey, H.W.:* Observations on the contractility of lacteals. J. Physiol. (Lond.) 62 (1927) 267

12 *Lieben, S.:* Über die Fortbewegung der Lymphe in den Lymphgefäßen. Z. Physiol. 24 (1910) 1164

13 *Hargens, A.R., B.W. Zweifach:* Contractile stimuli in collecting lymph vessels. Am. J. Physiol. 233 (1977) H57

14 *Pullinger, B.D., H.W. Florey:* Some observations on the structure and function of lymphatics. Brit. J. Exp. Path. 16 (1935) 49

15 *Hall, J.G., B. Morris, G.J. Wooley:* Intrinsic rhythmic propulsion of lymphatics in the unanaesthesized sheep. J. Physiol. (Lond.) 180 (1965) 336

16 *McHale, N.G., I.C. Roddie:* The effect of transmural pressure on pumping activity in isolated bovine lymph vessels. J. Physiol. (Lond.) 261 (1976) 255

17 *Kirkpatrick, C.T., N.G. McHale:* Electrical and mechanical activity of isolated lymphatic vessels. J. Physiol 272 (1977) 33P

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