BLOOD LYMPHOCYTE COUNT FOLLOWING THE LIGATION OF THE THORACIC DUCT IN MAN*†

KAZUHIKO AWAYA, AKIHO INADA, YASUNORI TANAKA, AND TOKIICHI KUWAHARA

Department of Anatomy
(Director: Prof. Bunsuke Osogoe)
Yamaguchi Medical School, Ube
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As reported by many workers (Biedl and von Decastello, 1901: Davis and Carlson, 1909–1910; Bunting and Huston, 1921; Lee, 1922; Blalock et al., 1937; Mann and Higgins, 1950; Hughes et al., 1956; Hansen, 1958), the lymphocytes in the peripheral blood markedly decrease in number either upon ligation of the thoracic or right lymph duct, or upon canulation of these lymph vessels to drain the lymph off.

Accordingly, it is beyond any doubt that the majority of the lymphocytes in the circulating blood reached the blood stream through the thoracic and right lymph ducts. However, such observations have so far been made mostly on experimental animals such as dogs, cats, rabbits or rats, and very few has been made on human subjects, for no ligation of the thoracic duct can be made in healthy people; it may be conducted only in such a special case as the chylothorax caused by a break of the thoracic duct (Goorwitch, 1955; Maurer, 1956).

In the literature, therefore, there are no reliable data on the changes in the number of lymphocytes in the circulating blood in man following the ligation of the thoracic duct.

Recently we have had an opportunity to obtain two cases of the ligation of human thoracic duct in operations performed in the Second Surgical Division of this Medical School. In these instances, the cerebrospinal fluid has been drained into the thoracic duct of the patients suffering from hydrocephlus internus. In this paper we wish to present, with some comments, the results of our observations made on the number of lymphocytes in the peripheral blood of these patients before, and during a period of more than one year following, the thoracic duct ligation. The detailed case report and the method of operation has been published elsewhere by Yokoyama et al. (1959).

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CASE REPORT

The ligation of the thoracic duct was conducted as the operation required for lowering the intracranial pressure by draining the cerebrospinal fluid of the patients with hydrocephalus into the thoracic duct. Following a right thoracotomia made at the lever of the 8th intercostal space, about 1 cm length of the thoracic duct was cut off at the height of the 9th thoracal vertebra, and the distal end of the duct were ligated. Then one end of a polyvinyl tubing was inserted into the lateral ventricle of the brain by a craniotomia and fixed on adjacent periosteum. The other end of the tube was introduced into the pleural cavitity through the postcranial and dorsal subcutaneous tissues, inserted into the proximal end of the cut thoracic duct and fixed there. The part of the polyvinyl tubing residing in the pleural cavity was fixed on the paravertebral tissue or periosteum of an adjacent rib. As the thoracic duct was ligated at the cranial side of the diaphragm at the height of the 9th thoracal vertebra, the pathway of the lymph and lymphocytes which had found their way into the blood through the thoracic duct was now blocked. On two patients undergoing such an operation, the change in the percentage and the absolute number of the peripheral blood lymphocytes was followed before and after the ligation of the thoracic duct.

Case 1. Male, 54 years old; underwent the above-mentioned operation because of the persistence of heightened intracranial pressure following the extirpation of a meningioma in the right posterior fossa. The results of the lymphocyte counts before and after the ligation of the thoracic duct of this patient are given in **Table 1** and **Figs. 1** and **2.** The percentage of the lymphocytes, which showed a relatively high values of 48.5, 48.5, and 49% on 3 examinations made before the ligation, dropped down to 20.0% immediately after ligation. This was further followed by low values like 17.6, 5.5, 9.5, and 12.0% 1, 2, 4, and 12 hours after the ligation, respectively. Thereafter, it tended to increase slightly, and reached relatively high values of 37% at the 5th and 40.5% at the 70th week. However, it showed a considerable fluctuation on consecutive examinations, and ultimately failed to attain the value obtained before the ligation.

As regards the absolute number of the lymphocytes, it fluctuated over a relatively wide range like 3,700, 6,500, 7,250 on 3 examinations prior to the ligation. It started to decrease, from immediately after the ligation onward, and reached a low value of 1,131 2 hours after the ligation. Until 24 hours after the ligation, the absolute number of the lymphocytes was maintained as low as less than 2,500, in spite of a remarkable increase in the number of leukocytes (13,600–23,600). It tended to increase slowly starting from the 3rd day, and, after a temporal approach to the lowest value observed before the ligation on the 8th day, it underwent a decline and a rise which repeated twice. It failed, however, to reach or surpass the

Table 1 Changes in the blood lymphocyte count aftet ligation of thoratic duct of a 54-year-old man, who underwent a shunting operation for hydrocephalus to drain cerebrospinal fluid into thoracic duct.

Time interval	Total number of leukocytes	Lymphocytes	
		Differential count (%)	Absolute number
Before ligation	14,800	49.0	7,252
	13,400	48.5	6,499
	7,600	48.5	3,686
Immediately after ligation	13,000	20.0	2,600
1 hour	21,400	17.0	3,638
2 hours	20,600	5.5	1,133
4 〃	23,600	9.5	2,185
12 〃	17,000	12.0	2,040
1 day	13,600	19.0	2,584
2 days	7,600	26.0	1,980
3 〃	7,000	25.5	1,785
5 〃	10,400	29.5	3,016
7 〃	12,200	27.0	3,294
10 〃	12,400	26.0	3,224
14 〃	9,400	13.0	1,222
3 weeks	7,800	29.0	2,262
4 〃	10,200	19.0	1,938
5 〃	7,200	37.0	2,664
6 〃	7,400	35.0	2,590
8 〃	14,600	30.0	4,380
9 〃	6,100	30.0	1,830
10 〃	9,000	25.0	2,250
11 〃	16,600	10.0	1,660
12 〃	19,200	16.0	3,072
14 〃	11,000	26.0	2,860
15 〃	11,600	26.0	3,016
70 〃	7,400	40.5	3,432

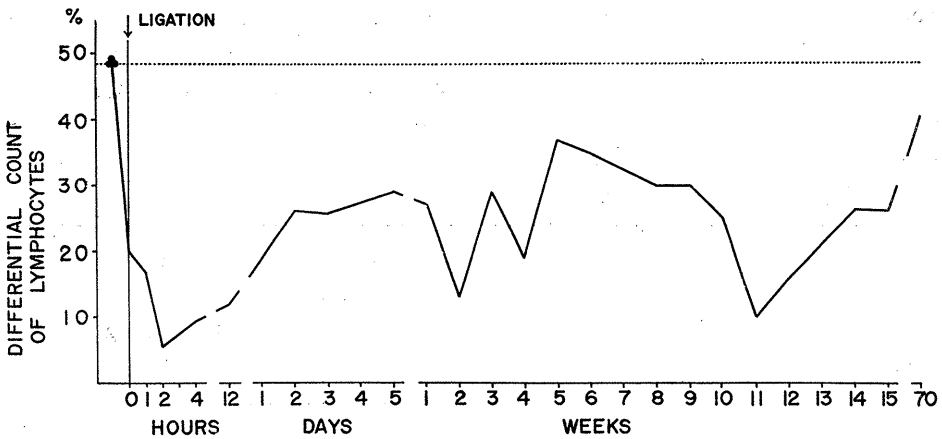

Fig. 1. Changes in the differential count of lymphocytes after ligation of thoracic duct.

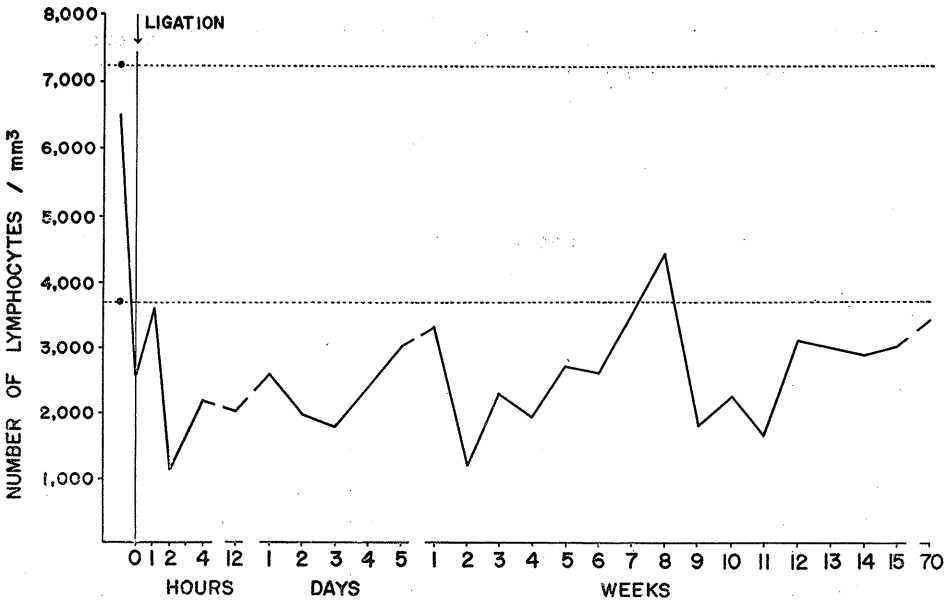

Fig. 2. Changes in the lymphocyte count (absolute number) after ligation of thoracic duct.

lowest value observed before the ligation even on the 70th week.

Case 2. Female, 29 years old; underwent the above-mentioned operation because of the hydrocepalus internus due to the blockade of the aqueduct of the midbrain caused by the gliosis. Results of the observations made on this subject are listed in **Table 2.** In this instance also, both percentage and absolute number of lymphocytes showed a marked decrease throughout the period from immediately after the ligation

Table 2. Changes in the blood lymphocyte count after ligation of thoracic duct of a 29-year-old woman, who underwent a shunting operation for hydrocephalus to drain cerebrospinal fluid into thoracic duct and died on the 10th day after operation.

Time interval	Total number of leukocytes	Lymphocytes	
		Differential count (%)	Absolute number
Before ligation	6,800	36.3	2,468
2 hours aftter ligation	8,200	11.0	900
6 hours	9,000	9.0	810
8 //	10,800	12.0	1,296
12 //	10,400	11.0	1,140
1 day	17,200	15.0	2,580
2 days	10,800	14.0	1,510
3 //	13,400	13.0	1,740
5 //	14,400	14.0	2,020
7 //	13,100	20.0	2,620
10 //	21,700	10.0	2,170

of the thoracic duct to the death on the 10th day, the most remarkable lymphopenia being noted 2 to 12 hours after ligation.

DISCUSSION

From what has been described of the above two cases, it can be stated that the consequence of the thoracic duct ligation revealed itself most strongly during the period of 12 hours immediately following the ligation, when percentage as well as absolute number of lymphocytes were diminished quite markedly. Beyond this critical period there was a trend of gradual recovery, but for more than 1 year in Case 1 and until the 10th day when the death took place in Case 2, the number of lymphocytes remained lower than the lowest value obtained before ligation.

As regards the literature on the changes in the number of lymphocytes in the peripheral blood following the ligation of the thoracic duct, there are several reports on the remarkable lymphopenia, which however disappeared around the third week, after the ligation of the thoracic (or thoracic and right lymph) ducts in several experimental animals like rabbits, dogs and cats. Goorwitz (1955) observed a recovery of the percentage of peripheral blood lymphocytes up to the pre-operative level during the third week following a clinical ligation of the thoracic duct conducted in a 44-year-old woman suffering from chylothorax caused by an external lesion. Also, Maurer (1956) reported a case in which the lymphocyte percentage in peripheral blood returned to the normal value on the 8th day after extirpation of thoracic duct in a 37-year-old woman with a benign tumor producing spontaneous chylothorax. Because of the lack of a detailed observation during 24 hours following the ligation or removal of the thoracic duct in these instances, it is not known whether there actually occurred a lymphopenia at all. The comparison of the results of the above workers with the ones obtained in the present study is compiled in **Table 3.** As was first observed here, a rapid decrease in the number of lymphocytes in the circulating blood following a thoracic duct ligation in human beings indicates that the majority of the lympocytes in the circulating blood is transported into the blood stream by way of the thoracic duct. In addition, the trend of a relatively early recovery from the severe lymphopenia which rapidly appeared upon ligation of the thoracic duct suggests an early formation of alternative lymphatic pathway.

SUMMARY

1. In order to drain the cerebrospinal fluid into the thoracic duct in patients suffering from hydrocephalus internus, operations were conduced in which the thoracic duct was cut off 1 cm long at the level of the 9th thoracal vertebra under a

Table 3. Comparison of the values of the lymphocyte count in the circulating blood after ligation of the thoracic duct or the thoracic and other main lymph ducts of both sides by different authors.

Time after ligation \ Reference / Material	Biedl and von Decastello (1901) Dog		Davis and Carlson (1909–1910) Dog		Bunting and Huston (1921) Rabbit		Lee (1922) Cat		Hansen* (1958) Cat		Goorwitch (1955) Human		Maurer (1956) Human		Table I, this paper Human	
	Per cent	Abs. no.	Per cent	Abs. no.	Per cent	Abs. no.	Per cent	Abs. no.	Per cent	Abs. no.	Per cent	Abs. no.**	Per cent	Abs. no.	Per cent	Abs. no.
before	12.9	2,147	22.6	4,308	53.0	4,770	24.0	3,139	—	3,000	30.0	9,120	19.0	—	48.5	3,686—7,252
2 hours	—	—	—	—	8.0	340	—	—	—	—	—	—	—	—	5.5	1,133
6—8 //	3.3	1,146	13.6	3,336	—	—	—	—	—	—	—	—	—	—	—	—
12 //	—	—	—	—	5.0	310	3.6	1,373	—	—	—	—	—	—	12.0	2,040
20 //	—	—	10.03	2,463	—	—	—	—	—	—	—	—	(7.0)***	—	—	—
1 day	1.6	452			15.0	1,005	6.7	1,288	—	800	6.0	768	—	—	19.0	2,584
4 days	6.8	1,523			13.0	1,251	5.7	1,482	—	1,000	—	—	—	—	—	—
7—8 //	6.2	1,133			—	—	7.7	1,293	—	—	7.0	840	19.0	—	27.0	3,294
9—10 //					40.5	3,118	5.0	1,064	—	1,400	—	—			26.0	3,224
13—14 //							11.3	2,160	—	1,600	—	—			13.0	1,222
20—21 //							21.3	3,118	—	2,300	32.0	3,840			29.0	2,262
25 //									—	3,200	—	—			—	—
7 weeks											39.0	3,198			—	—
8 //											—	—			30.0	4,380
11 //											19.0	1,758			10.0	1,660
37 //											38.0	—			—	—
70 //															40.5	3,482
Remarks	Thoracic and right lymphatic ducts ligated		Thoracic and cervical lymph ducts ligated		Thoracic and right lymphatic ducts ligated		Thoracic duct ligated		Thoracic duct ligated		Thoracic duct ligated		Complete extirpation of thoracic duct		Thoracic duct ligated	

* These values were calculated from the data illustrated in Fig. 18 of the original paper.

** The figures of this column were calculated from the original data.

*** This value was obtained on the day of operation, but the exact time of sampling was not indicated.

right thoracotomia, the distal end of the duct being ligated while the proximal end connected with a polyvinyl tubing with the lateral ventricle. On two patients with the thoracic duct ligated, observations were made of the pre- and post-operative changes in the number of lymphocytes in the peripheral blood.

2. In Case 1 (54-year-old, male), the percentage and absolute number of lymphocytes in peripheral blood decreased markedly during the period of 2 to 12 hours after the ligation of the thoracic duct. Thereafter the sign of a relatively early recovery was obtained, but the lymphocyte count was maintained at a level inferior to the lowest value obtained prior to the ligation throughout a period of 70 weeks.

3. In Case 2 (29-year-old, female), the patient died on the 10th day after operation; the percentage and absolute number of lymphocytes in the peripheral blood decreased remarkably during the 2nd to 12th hours after the ligation of the thoracic duct, a marked lymphopenia persisting until the 10th day on which the patient died.

4. The observations made on the human lymphopenia caused by the thoracic duct ligation are in a fairly good agreement with the ones reported by previous workers on the experimental animals, indicating that the majority of the lymphocytes in the circulating blood is transported into the blood stream by way of the thoracic duct. In addition, the trend of a relatively rapid recovery from the lymphopenia caused by the thoracic duct ligation suggests an early formation of alternative lymphatic pathway.

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