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# Cervical Lymphato-Venous Shunt in Treatment of Ascites in Caval-Constricted Dogs and in Patients with Hepatic Cirrhosis

## Experimental observations and 7 years clinical experience

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*Summary*

In experimental ascites produced by inferior vena caval constriction there is a pressure gradient at the thoracic duct-venous junction suggesting a functional obstacle to lymph flow. Abdominal fluid and protein are transported mainly by the right lymph trunk and not by the thoracic duct. External drainage of the thoracic duct or construction of a new, wider thoracic duct-venous anastomosis facilitates, however, transport of excess capillary filtrate formed in the liver and decreases fluid spillage into the peritoneal cavity.

Construction of a cervical lymphato-venous anastomosis was attempted in 21 patients, 20 of whom had cirrhosis, and the operation was technically successful in 16 cases. Operation was helpful in cirrhotic patients with rapid ascites formation, who required less frequent abdominal paracenteses operation. The shunt was without benefit in prevention of oesophageal varix bleedings, and it should not be attempted in patients with icterus and severe deterioration of liver function.

**Key Words:** Ascites – lymphato venous shunt in; lymphato-venous anastomosis in ascites; lymph flow in experimental ascites peritoneal cavity – lymphatic drainage; thoracic duct – resistance at orifice of

In most patients suffering from cirrhosis of the liver ascites formation can be controlled by dietetic measures and administration of diuretics. There are, however, some cases where rapid abdominal fluid accumulation cannot be effectively managed. These patients often undergo repeated abdominal paracenteses with the attendant danger of fluid, electrolyte and protein losses.

In patients with hepatic cirrhosis the thoracic duct is greatly dilated, contains fluid under pressure, and when vented large amounts of fluid escape (7, 15, 26). It has been suggested that a functional narrowing at the veno-lymphatic junction restricts flow of excess lymph formed in the liver (3, 8). External drainage of the thoracic duct or construction of a lymphato-venous anastomosis was proposed, therefore for treatment of intractable ascites (5, 6, 22). The first publications reported a decrease of liver size, disappearance of ascites and reduction of portal venous pressure after this maneuver. Since then a number of favorable reports has appeared on the effect of thoracic duct fistula and of lymphato-venous shunt in patients suffering from intractable ascites due to liver cirrhosis (1, 18, 20, 25).

On the other hand, shunt operations and thoracic duct drainage were criticized on several grounds. No pressure gradient was found at the thoracic duct orifice; accordingly, it was concluded that there was no substantiation for a relative obstruction inhibiting outflow of excess lymph (8, 24). Indeed, the original reports only described increased thoracic duct *end* pressure in experimental and clinical ascites. Thus, whether *side* pressure or *transmural* pressure in the intact lymphatic system was also increased has not been demonstrated (21).

In patients with cirrhosis and ascites cannulation of the thoracic duct decreases circulating plasma volume and, thereby lowers central and hepatic venous pressures (17, 23, 24). The concomitant fall of sinusoidal pressure decreases capillary filtration in the liver and fluid spillage into the abdominal cavity. Unfortunately, because of electrolyte and protein losses, external drainage of the thoracic duct is feasible only for a short period. However, lymphato-venous anastomosis may have a more prolonged benefit. If the main obstacle to adequate lymph drainage is obstruction at the lympho-venous junction then transsection of the duct and construction of a new, wider orifice might be beneficial, with the advantage of no external fluid, electrolyte

and protein losses. On the other hand, if there is no fluid loss it might be anticipated that systemic venous and sinusoidal pressures may not decrease and accordingly, ascites formation may persist (10, 17).

These contradicting opinions stimulated further experimental investigation of these problems. Based on these findings we have been encouraged to apply cervical lympho-venous shunts in patients. Our experimental and clinical observations are summarized here.

A. *Experimental Part*

1. *Pressure gradient at the thoracic duct orifice*

Venous stasis in the liver was produced in dogs by supradiaphragmatic constriction of the inferior vena cava (22). In control experiments systemic venous congestion was produced by constrictive pericarditis (21). Pressure in the terminal part of the thoracic duct and in the innominate vein, near the veno-lymphatic junction, was measured with a strain gauge. The pressure measurements were made through a small collateral branch of the subclavian vein. In other animals a small gauge (No. 3) hypodermic needle was inserted directly into the respective vessels. No significant difference was found between the pressure readings made by the two methods.

In 27 normal dogs mean pressure in the intact thoracic duct was 5.2 ± 0.4 mmHg and cervical venous pressure 5.8 ± 0.4 mmHg, i.e. under normal conditions there is no positive gradient between central lymphatic and venous pressures. In 10 dogs with constriction of the inferior vena cava, cervical venous pressure was 1.0 ± 0.3 mmHg and lymphatic pressure 7.9 ± 0.8 mmHg. Finally, in 17 dogs with systemic venous congestion produced by constrictive pericarditis lymph pressure was 16.9 ± 1.4 mmHg and cervical venous pressure 16.7 ± 1,4 mmHg. The results suggest in dogs with inferior vena caval constriction there is a pressure gradient at the lympho-venous junction. The low venous pressure readings in these dogs do not negate an obstacle to lymph flow at the orifice. On the other hand, with systemic venous congestion the average central venous pressure is high and this explains elevation of lymph pressure.

Accordingly, alteration of the orifice, i.e. construction of a new lympho-venous junction in the animals with inferior vena caval obstruction (Fig. 1) reduced the pressure gradient. The technique of the operation will be described in the clinical part of this paper.

2. *Effect of lymphatic drainage*

In dogs, under general anesthesia, a cannula was introduced into the cervical part of the thoracic duct and into the right lymph trunk. In the 1st groups (controls, 11 animals) $I^{131}$ labelled human albumin was added to 10 ml/kg body weight diluted dog plasma and injected into the abdominal cavity. Lymph was then collected from both cannulated vessels for 6 hours. In the 2nd group (9 animals) the thoracic duct was cannulated and on the right side of the neck all lymphato-venous connections were interrupted. This was done by isolating the great cervical veins of the right side and transsecting between bulk ligatures adjacent tissue. These dogs received again 10 ml/kg diluted homologous plasma labelled with $I^{131}$-albumin. In the 3rd group (ascites, 10 dogs) prior to experiment, peritoneal fluid accumulation was produced by caval constriction. The dogs received 1 ml/kg homologous plasma labelled with radio-albumin. Lymph was collected in this group, as in the 1st group, from both cervical lymph trunks.

After cannulation in dogs with ascites the outflow of lymph from the thoracic duct was greatly increased. The flow rate was about 6 times higher than in the controls. Lymph flow decreased, however, during the experiment. In controls, on the other hand, a progressive increase of flow was observed. Accordingly, at the end of the experiment (in the 5th hour) in controls and in dogs with caval constriction thoracic duct lymph flow was about equal. In the latter group an increase of right lymph duct flow was also noted. Due to the great fluid loss from the cannu-

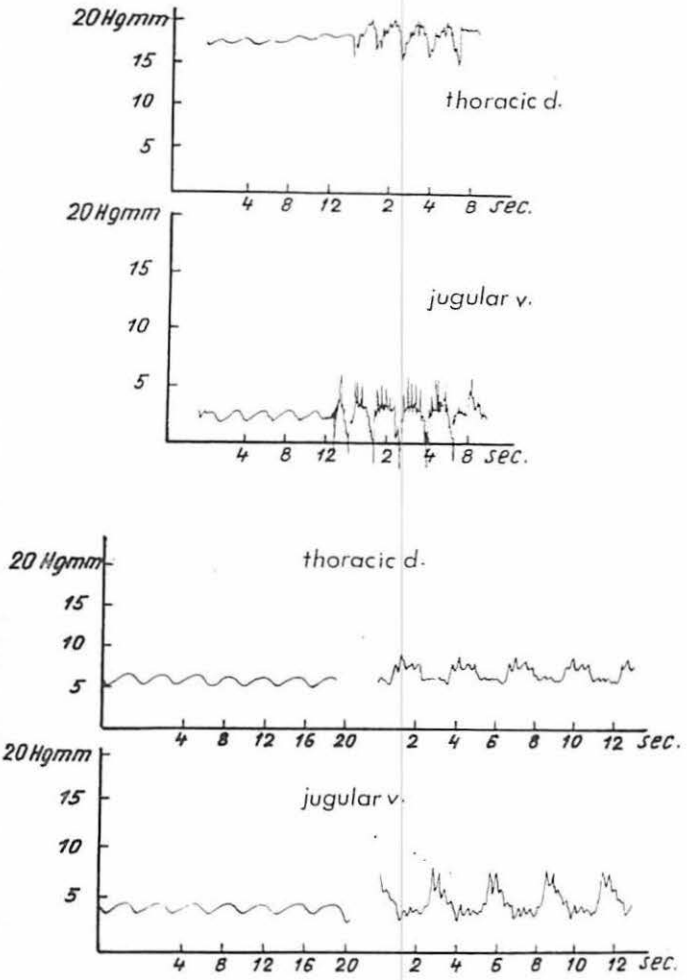


Fig. 1 Pressure in the cervical part of the thoracic duct and the external jugular vein in a dog with ascites due to inferior vena cava constriction.
Upper row: before operation;
Lower row: 3 weeks after the construction of a cervical lymphatico-venous anastomosis.

lated lymph vessels (37.5 ± 3.6 ml/kg in 6 hrs) the increased circulating plasma volume in dogs with ascites was reduced by an average of 13.3 ml/kg. At the same time inferior vena caval pressure decreased in 6 hours from 17.0 ± 0.9 mmHg to 7.0 ± 0.5 mmHg. Both in normal dogs and in dogs with ascites, the previously placed peritoneal fluid, or more precisely, the protein in this fluid was transported mainly by the right lymph trunk and not by the thoracic duct. In controls 7 ± 2.1% of the injected radioalbumin was eliminated in 6 hours through the thoracic duct, 15.6 ± 3.5% through the right lymph duct and 11.8% was found in circulating plasma. After ligation of the lymphatics of the right side (2nd group) recovery in blood plasma was reduced to 6.1% of the original dose. It was calculated from the above data, that the lymph channels joining the great veins in the right side of the neck (tr. lymphaticus dexter and some other smaller vessels) transport in 6 hours about 21.3% of the protein content in the abdominal cavity, i.e. about 3 times as much, as the thoracic duct. In dogs with ascites thoracic duct transport was 1.20 ± 0.3%, the transport by the right trunk 1.66 ± 37% and 1.54 ± 0.32% gained access to the circulating plasma. This finding does not signify, however, that in ascites, protein absorption and lymphatic transport are diminished. The labelled albumin is diluted in these experiments by the peritoneal protein pool, which is obviously much greater in the

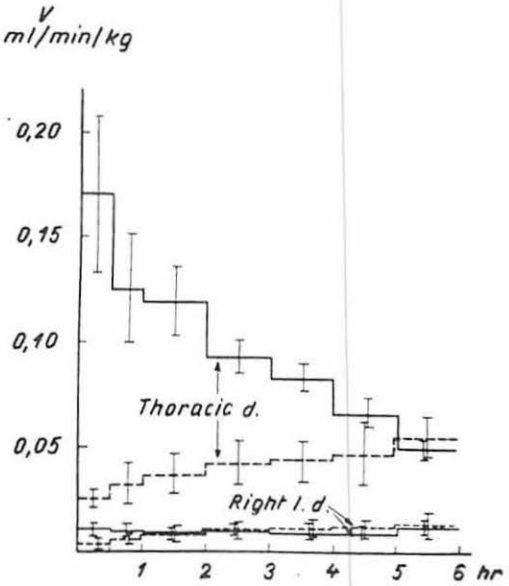


Fig. 2 Lymph flow in the thoracic duct and right lymph duct after ductal cannulation.
*Continuous lines:* dogs with ascites due to caval constriction.
*Interrupted lines:* normal dogs after intraperitoneal injection of 10 ml/kg diluted homologus plasma.

presence of substantial ascitic fluid. Accordingly, it was calculated that in controls, protein transport from the abdominal cavity by the thoracic duct amounted in the 5th hours after cannulation to 0.07 g and 0.14 g was transported by the right trunk. In dogs with ascites, thoracic duct protein transport was 0.12 g and the transport by the right trunk 0.17 g. In both cases only 4-5% of the total amount of protein transported by the thoracic duct and nearly 50% of the protein in the right duct lymph was of abdominal origin. Thus the data suggest, that the great increase of lymph flow observed after cannulation of the thoracic duct is not a consequence of absorption of ascitic fluid. The major part of protein (and fluid) absorbed from the abdominal cavity is not transported by the thoracic duct but by lymph vessels joining the great veins at the right side of the neck. The tremendous increase of thoracic duct lymph flow is a consequence of increased sinusoidal pressure and capillary filtration in the liver. The lymphatics drained by the thoracic duct are transporting mainly this excess capillary filtrate. In the present experiments mean inferior caval pres-

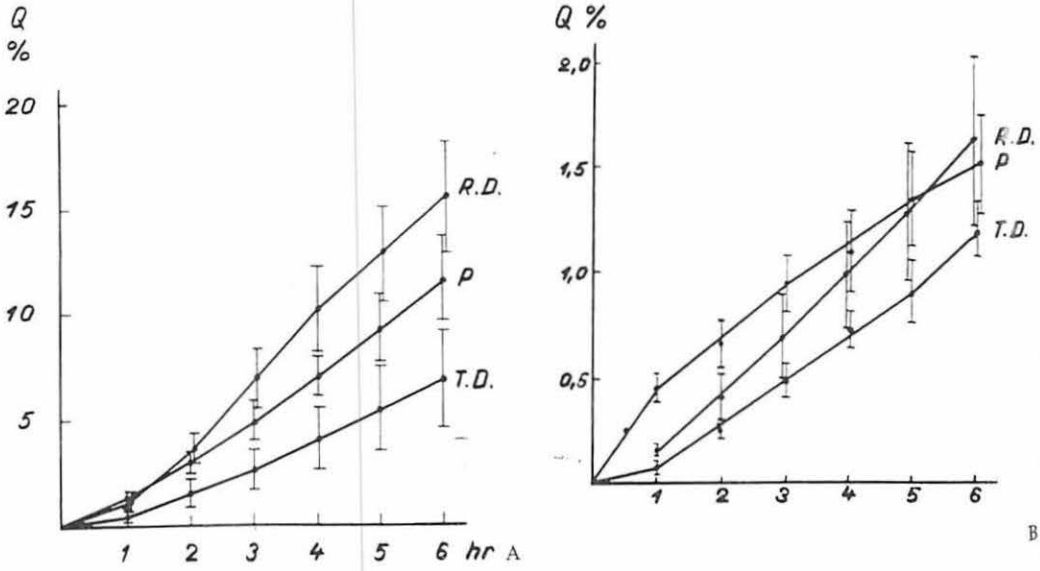


Fig. 3 Lymphatic and venous transport of protein from the abdominal cavity in normal dogs (A) and in dogs with experimental ascites (B).
The normal animals received labelled albumin diluted with 10 ml/kg protein solution. The ascitic animals had an average fluid accumulation of 97 ml/kg and received the label in 1 ml/kg homologous plasma.
Q%: per cent recovery of the introduced label in plasma or lymph;
R.D.: right lymph duct; T.D.: thoracic duct: P: circulating plasma.

sure decreased in 6 hours by an average of 10.0 mmHg and thoracic duct flow by 0.121 ml.-$min^{-1}$ kg body $weight^{-1}$ corresponding to a flow change of 0.042 ml. $min^{-1}$ $mmHg^{-1}$ 100 $g^{-1}$ liver weight. This may be compared to the filtration coefficient of the liver capillaries which was in the cat 0.060 ml. $min^{-1}$ 100 $g^{-1}$ (12).

The reduction of thoracic duct lymph flow during prolonged cannulation is, however, probably not due exclusively to a decrease of capillary filtration in the liver. The greatest fall in lymph flow was observed in the first 30 minutes after cannulation (0.045 ml. $min^{-1}$ $kg^{-1}$). In the consecutive 5 hours the average half-hourly decrease was 0.007 ± 0.0003 ml. $min^{-1}$ $kg^{-1}$ These findings suggest fluid accumulation in the lymphatic system and corroborates the presence of an obstacle to outflow of lymph at the venolymphatic junction.

*3. The effect of lymphato-venous anastomosis*

The effect of a cervical lymphato-venous shunt was investigated in 14 dogs with ascites from inferior vena caval constriction. In 14 control dogs ascites was produced by the same method. but a sham-operation only was performed in the neck and no shunt was constructed. The anastomosis was established in 10 dogs 5 to 9 days (avg. 7 days) after caval constriction and in 4 dogs after prolonged observation (105–240 days). Each animal had massive ascites at time of operation: the abdominal girth was increased by more than 10 cm and the peripheral venous pressure, measured in the hind legs, was elevated by 10 to 13 mmHg.

At the end of the experiment (after 3 to 12 months), as established by lymphography, the anastomosis was open in 12 dogs and occluded in 2. In 9 of the successfully operated 12 dogs the ascites was substantially reduced in the 1st week after operation. No change was seen in 3. The late results were also favorable: 58% (7 from 12 animals) remained free of ascites during the whole time of observation. The results were, however, much less impressive if they are compared with the observations in sham operated dogs. In this group ascites was present during the entire period in only 43%, in 3 dogs (21% it disappeared completely and in 5 (36%) it was intermittent, i.e. it disappeared but after a more or less prolonged interval reappeared again. The shunt seemed to be, nonetheless, with some effect in experimental ascites. The effect must be based on better drainage of excessive capillary filtrate formed in the liver. The filtration itself was probably not diminished, because there was no external fluid loss, the circulating plasma volume did not decrease, and the central and hepatic venous pressures were not reduced. Actually, in the present experiments the average maximum decrease of inferior caval venous pressure was 2.7 S.D. ± 1.7 mmHg, but a similar change (2.3 S.D. ± 2.8 mmHg) was seen in sham operated dogs.

The better drainage of capillary filtrate diminished, however, fluid spillage form the liver surface and consequently, formation of ascites.

B. *Clinical Observations*

Construction of a lymphato-venous shunt was attempted in 21 patients, twenty of whom were suffering from liver cirrhosis. In 15 patients the leading symptom was ascites, in 2 varix bleeding and in 3 patients there was both ascites and varix bleeding. The final patient had carcinosis peritonei with ascites.

All patients operated upon were in poor condition. In these patients where ascites was the leading symptom, they were generally drug resistant and a paracentesis was performed every 1 to 2 weeks. Five patients had one or several varix bleedings before operation, hepatic coma was recorded in 11 patients and 4 had jaundice at time of operation. In all these patients preoperative lymphography was helpful. For various reasons it could be performed only in half of the cases. Lymphography gave important information about anatomical variations, size of the duct, type

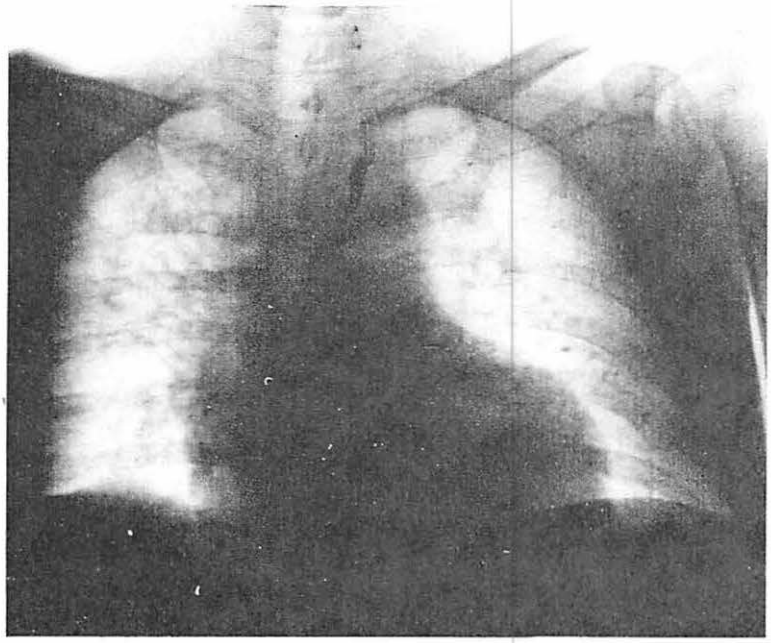

Fig. 4 The thoracic duct in a patient with liver cirrhosis and ascites after construction of a lymphato-venous shunt.

of orifice, and the rapidity of lymph flow. Nonetheless, lymphography should be interpreted with caution as it does not in itself establish the indication or contraindication for operation. Postoperative lymphography substantiated functioning of the shunt.

*Surgical technique.* An incision is made along the left internal jugular vein on the base of the neck. The thoracic duct is identified and a ligature is placed around it near the orifice. All small tributaries are cut between ligatures. According to the relative positions of the duct and of the veins, the external or the internal jugular vein is doubly ligated and transsected between two ligatures. The proximal stump of the vein is then prepared for anastomosis. Three No. 0/6 atraumatic sutures are first introduced into the wall of the thoracic duct and then into the vein. The stump of the lymph vessel is now cut off, together with the ligature, and the thoracic duct is invaginated into the vein. The side pressure keeps the thin-walled lymph vessel open and adhering to the walls of the vein.

For anatomic reasons, an anastomosis could not be constructed in 4 of the 21 patients. In 2

Table 1 Survival times and causes of death in operated patients.

| Survival time months | | Cause of death | | | | | |
|---|---|---|---|---|---|---|---|
| | | carcinoma | bleeding | hepatic coma | intercurrent dis. | Living | Total |
| – 6 | without shunt | | 1 | 4 | | | 5 |
| – 6 | with shunt | 3 | 2 | 1 | 1 | | 7 |
| 6–12 | with shunt | | | 3 | | | 3 |
| 12–18 | with shunt | | | | 2 | | 2 |
| 18–24 | with shunt | | 1 | | | | 1 |
| 24– and over | with shunt | | | | | 3 | 3 |
| Total | | 3 | 4 | 8 | 3 | 3 | 21 |

Table 2 The effect of lympho-venous shunt in liver cirrhosis.

| No. | Patient age | sex | Before operation duration of ascites | frequency of paracent. | diuretics weekly dose | After operation weight loss kg | frequency of paracent. | diuretics weekly dose | observat. time | Cause of death | Autopsy finding |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 46 | m | 6 y | every 6 w. | 56 H | 16 | Ø | 6 F | 18 m | accident, peritonitis | shunt open |
| 2 | 57 | m | 4 y | every 8 w. | 16 H | 8 | Ø | 2 F + 1 H | 6 y | living | |
| 3 | 71 | m | 5 m | every 6 w. | 6 H + 3 F | 5 | Ø | 2 F + 1 H | 14 m | pneumonia | |
| 4 | 68 | m | varix bleeding | – | – | – | – | – | 2 m | varix bleeding | shunt open |
| 5 | 61 | m | 1 y | every 2 w. | 6 F + 1 E | Ø | every 2 w. | – | 2 m | carcinosis peritonei | shunt open |
| 6 | 63 | m | 2 y | 2 x before op. | 24 E + 6 SP | 20 | Ø | 1 E + 10 SP | 4 y | living | |
| 7 | 57 | m | 18 m | 1 weekly | 32 F + 12 SP | 10 | every 8 w. | 9 E + 12 SP | 4 m | varix bleeding | shunt open |
| 8 | 62 | m | varix bleeding | – | – | – | – | – | 4 m | varix bleeding | shunt open |
| 9 | 55 | f | 3 y | every 12 w. | 8 E + 12 F | 7 | Ø | 2 F | 3 y | living | |
| 10 | 66 | f | 3 y | 1 weekly | 7 E + 7 F | 5 | every 5 w. | 4 F | 6 m | hepatitis, coma | |
| 11 | 46 | m | 18 m | every 2 w | 56 SP + 12 F | 6 | Ø | 36 SP + 4 F | 4 m | liver carcinoma | shunt open |
| 12 | 68 | m | 2 m | 1 weekly | drug resistent | 3 | Ø | | 6 w | liver carcinoma | |
| 13 | 53 | m | 18 m | 1 weekly | 28 SP + 6 F | 8 | Ø | 32 SP + 4 F | 7 m | hepatic coma | |
| 14 | 39 | m | 24 m | 1 weekly | drug resistent | 5 | Ø | 42 SP + 4 F | 2 w | sepsis | |
| 15 | 53 | f | 20 m | 1 weekly | drug resistent | 8 | Ø | 42 SP + 4 F | 7 m | hepatic coma | |
| 16 | 33 | f | 20 m | 1 weekly | drug resistent | | | | 4 d | hepatic coma | shunt closed |
| 17 | 52+ | m | 9 m | 1 weekly | 9 F + 3 H | Ø | 1 weekly | 9 F + 3 H | 6 m | hepatic coma | |
| 18 | 58+ | m | 12 m | every 4 w | 8 F + 8 H | Ø | every 4 w | 8 F + 8 H | 4 m | varix bleeding | |
| 19 | 57+ | m | 18 m | every 2 w | 7 F + 6 SP + 7 E | Ø | every 4 w | 7 F + 6 E | 4 m | hepatic coma | |
| 20 | 57+ | m | 12 m | – | 28 SP + 6 F | Ø | – | 28 SP + 6 F | 2 m | hepatic coma | |
| 21 | 45++ | m | 10 y | every 8 w | 9 H | – | every 8 w | | 6 m | hepatic coma | |

+: no anastomosis constructed

++: d. thoracicus ligated after the operation

Medication: H: hypothiazid (25 mg); SP: spironolacton (25 mg); E: etacrynic acid (50 mg); F: furosemide (40 mg); (tablets)

cases the thoracic duct could not be approached from the cervical incision; in another 2 cases the thoracic duct was divided in several small branches. In the 5th case the duct slipped out from the vein and a large lymph loss ensued, which could be controlled only by ligation of the duct. These 5 patients have been considered as a "sham operated" control group.

Anastomosis was successful in 16 patients. Two patients died shortly after operation; 1 on the 3rd postoperative day from hepatic coma; and in another, the cause of death was sepsis on the 16th day from a previously unrecognized prostatic abscess. The state of the patient whose ascites was due to carcinosis peritonei did not change after operation. This patient died after 4 months. At autopsy it was established that the anastomosis had been functioning.

In 2 patients operation was performed for relief of varix bleeding and they died 2 and 4 months later from repeated varix bleedings. The shunts were open at autopsy.

In 11 successful operated cases, where the leading symptom was ascites, a decrease of abdominal fluid accumulation and an improved responsiveness to diuretic drugs occurred. Abdominal paracenteses were no longer required. Three of these patients are now living, 6,4 and 3 years, respectively and 6 other patients have survived 6 to 21 months. Two patients lived only $1\frac{1}{2}$ and 4 months. They were practically free of ascites and, died from complications of hepatic carcinoma.

In the 6 patients, who survived 6 to 21 months, 1 died after 18 months from a traffic accident, 1 after 14 months, at 72 years, from pneumonia, 1 patient after 21 months from varix bleeding and 3 patients after 7, 7 and 6 months respectively, from hepatic coma. (Table 2).

The postoperative survival of the 5 "controls", i.e. of the patients, where operation was attempted, but no shunt could be constructed, was less than 6 months. The cause of death was in 1 case varix bleeding and in 4, hepatic coma.

C *Discussion and Conclusions*

Observations in dogs with inferior vena caval constriction and in patients with cirrhosis confirm the value of a cervical lymphato-venous shunt in treatment of ascites. Some authors have considered bleeding esophageal varices as an indication for operation (2, 10, 25). We attempted a lymph shunt in 5 patients with varix bleeding (3 of them had also ascites). Even when the lymph shunt was successful in 4 patients, 3 died, 2, 4 and 21 months, respectively after operation from repeated varix bleedings. One patient is alive (3 years after the shunt operation). The patient in whom an anastomosis could not be constructed died 6 months afterwards. Although the number of cases is small, it can be nonetheless concluded, that they do not confirm any beneficial effect of lymphato-venous anastomosis for esophagus varix bleeding. In ascites due to liver cirrhosis the results are more encouraging (1, 10, 18, 20). In patients who had a successful lymph shunt, there was a significant decrease of abdominal fluid accumulation. However, this procedure had only a palliative effect, and its main advantage is that these patients did not require frequent abdominal paracenteses. Thus, each operated upon patient suffered from severe cirrhosis. Out of the 21 cases, 15 had severely deranged liver function tests, 11 had one or more episodes of coma and 4 were jaundiced at time of operation. In this latter group the prognosis was poor. One patient did not regain consciousness after anesthesia and died 3 days after operation from hepatic coma. Two patients died 7 months later, again from coma, 1 patient died from sepsis on the 16th postoperative day and 2 later with liver carcinoma. If these cases, as well as deaths due to intercurrent disease (traumatic osteomyelitis, sepsis, peritonitis due to injury, etc) were omitted, then the survival of the successfully operated patients (2 to 6 years) was significantly longer than the unsuccessfully operated "control" group (less than 6 months).

From the above considerations, it may cautiously be concluded that in "cirrhotic" patients with moderate hepatic dysfunction a lymphaticovenous anastomosis is beneficial not only in

alleviating ascites formation but also in prolonging survival. Severely deranged liver function, varix bleedings and coma do not totally counterindicate the procedure, but it should be not attempted in patients with prolonged jaundice. Finally, this procedure is without benefit in patients with varix bleeding and no ascites.

The only local postoperative complication observed was oozing of lymph from the cervical wound, in 4 cases. In 3 it was moderate and stopped after a few days or 1 to 2 weeks. In one patient lymph loss reached nearly 4 liters daily and it was necessary to ligate the thoracic duct. In this patient, ascites disappeared during the period of free outflow of lymph, but reaccumulated when the duct was ligated. After 6 months, his general condition was unchanged and he died shortly afterward, from hepatic coma.

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