

VI. "Interference with Icterus in Occluded Ductus Choledochus." By VAUGHAN HARLEY, M.D. Communicated by GEORGE HARLEY, M.D., F.R.S. Received March 23, 1892.

(From the Physiological Institute, Leipzig.)

In 1880, Kufferath* pointed out that when both the ducti thoracici—right and left—and the ductus choledochus are ligatured icterus does not appear. From his having only kept the dogs experimented upon alive from 1 to $2\frac{1}{2}$ hours, I was induced to test the value of the statement by a series of experiments on animals kept alive for much longer periods.

The following are the results obtained, conducted under the guidance of Professor Ludwig, to whom my best thanks are due for the valuable assistance he gave me.

The health of the animals experimented upon, I found, was not disturbed by ligaturing the thoracic duct, if, after being kept fasting a few days, they were carefully fed upon a fat-free diet; and not only so, but that they might live for weeks and months and even increase in weight. Nor did the additional ligaturing of the common bile duct prove dangerous if done a few days previous to the application of the ligature to the thoracic duct, and the dogs fed on food containing only small quantities of proteids.

On the other hand, when both the thoracic and bile ducts were ligatured at the same time, the animals frequently died a few days after the operation, in consequence of rupture of the common bile duct and the escape of bile into the peritoneal cavity inducing fatal peritonitis.

The experiments were conducted as follows:—After being operated upon, each dog was kept separately in a place suitably arranged for collecting its urine, which was daily examined for bile pigment by Gmelin's test, and for bile acid (after being treated according to Hoppe Seyler's method) by von Udranszky's test. After the death of the animal the bile in the gall bladder was analysed. The portal blood-vessels were injected, and, although the bile capillaries were greatly distended, all attempts made to inject them proved unsuccessful. In order to ascertain if the thoracic duct had been properly ligatured it was carefully examined, and then injected with Berlin blue, so as to find out if it had opened up any collateral lymphatics, through which its lymph could find access to the general circulation.

Of eighteen dogs thus experimented upon, two having died from

* Kufferath, "Ueber die Abwesenheit der Gallensäure im Blute nach dem Verschluss des Gallen- und des Milchbrustganges" (Du Bois-Reymond's 'Archiv f. Physiol.', 1880, p. 92.)

blood poisoning from three to four days after the operation, they are not included in the following tables.

Of the sixteen dogs which survived the operation—from the day after both their thoracic and bile ducts were ligatured—eight passed urine containing neither bile pigment nor bile acid. In all of these cases the thoracic and common bile ducts had been ligatured at the same time.

Results arranged according to the duration of life.

No. of experiment.	Lived.	Bile absent from the urine for	Cause of death.
1	20 days	11 days	Killed.
5	18 "	17 "	Rupture of bile duct.
2	7 "	7 "	Peritonitis.
6	7 "	6 "	Rupture of bile duct.
4	5 "	4 "	" " "
3b	4 "	4 "	" " "
3a	3 "	3 "	Peritonitis.
10	3 "	2 "	Rupture of bile duct.

In the remaining eight cases the thoracic duct was ligatured some days after the common bile duct, and in them the bile pigment and bile acid, which had appeared in the urine as soon as the bile duct was ligatured, disappeared from it on the thoracic duct being also operated upon, except in those cases where a sufficient time had been allowed to elapse after the two operations to admit of collateral lymphatics being formed.

Table of Results obtained, arranged according to the time allowed to elapse between the two operations.

No. of experiment.	Thoracic duct ligatured after the choledochus.	Urine contained bile until	Urine free from bile.	Killed.
7	On 13th day.	26th day.	..	27
14	" 9th "	56th "	..	56
13	" 7th "	23rd "	..	23
8	" 6th "	14th "	From 15th to 18th day.	18
9	" 6th "	11th "	..	11
15	" 5th "	6th "	From 6th to 13th day, returned on the 14th day.	31
17	" 4th "	16th "	..	16
16	" 2nd "	7th "	From 7th to 15th day.	28

By careful post-mortem examination it was ascertained that in every case in which bile appeared in the urine, after ligaturing the thoracic duct, the bile had reached the general circulation by the development of collateral lymphatic vessels. These were found to leave the thoracic duct at a point under the first rib and proceed from thence to join the right innominate vein. The only other occasions on which bile was found in the urine, after ligature of the thoracic duct, were in those cases where rupture of the bile duct occurred, and allowed its contents to escape into the peritoneal cavity.

In every case examined, not only was bile pigment, but also bile acid, found in the lymph of the dilated thoracic duct.

Tiedemann and Gmelin,* Fleischl,† and Kunkel‡ had already pointed out that when the ductus choledochus is ligatured and the lymph collected from the thoracic duct it is rich both in bile pigment and bile acid, whereas the blood remains entirely free from bile.

The analyses of the bile taken from the gall-bladders of the dogs in which a communication between the thoracic ducts and the right innominate vein had been established by the development of collateral lymphatic vessels, thereby permitting bile to reach the general circulation, showed that, in these instances, the bile neither contained an increased quantity of soluble substances nor of taurocholate of soda, but merely an excessive amount of mucin.

The following table contains the results obtained from the analyses of bile taken from the gall bladders of four of the dogs operated upon, and of two other healthy dogs. The amount of taurocholate of soda was calculated from the quantity of sulphur found in an absolute alcohol extract of the dried residue left after the removal of mucin, and other substances soluble in ether (cholesterin, fat, and lecithin).

Analyses of Bile from Gall Bladders.

No. of experiment.	Lived.	Mucin.	Dried residue.	Taurocholate of soda.
13	23 days	3·706 p.c.	16·164 p.c.	13·359 p.c.
15	31 "	1·991 "	7·974 "	4·628 "
5	18 "	1·231 "	11·810 "	7·661 "
8	18 "	1·183 "	15·084 "	9·415 "
Normal dog	..	0·746 "	22·460 "	
" "	..	0·691 "	11·732 "	6·620 "

In those cases where the bile did not appear in the urine for some

* Tiedemann u. Gmelin, 'Die Verdauung nach Versuchen,' vol. 2, 1827, p. 40.

† E. Fleischl, 'Arbeit. d. physiol. Anst. zu Leipzig,' 1875, p. 24.

‡ A. Kunkel, *ibid.*, 1876, p. 116.

days after ligaturing the ducts (Experiments 1, 2, 5, &c.), the bile ducts were found so greatly increased in size that on making a section of the liver, even the so-called bile capillaries could be seen by the naked eye without the aid of injection. In all cases where the blood vessels were filled with injection, and the liver hardened in a solution of bichromate of potassium, free spaces were found between the blood capillaries and the liver cells. These appeared to be the perivascular lymph spaces of MacGillavry* and Budge.† The enlargement of the perivascular lymph spaces seem to have taken place at the cost of the liver cells, for not only did the cells themselves appear to be much smaller, but the nuclei of the neighbouring hepatic cells appeared to be closer together than normal.

Three conclusions may apparently be drawn from the results obtained from these experiments :—

Firstly. That bile existing in the bile ducts can only reach the blood through the intervention of the lymphatics.

Secondly. Seeing that lymphatics surround the liver blood vessels, one is forced to believe that bile pigment and bile acid cannot pass through the endothelium of the blood capillaries in the liver; or, perhaps, even throughout the body. The fact that bile reaches the blood when it has escaped into the peritoneal cavity is no argument against this view. For in that case it would reach the blood through the lymphatics of the diaphragm.

Thirdly. After the left thoracic duct has been ligatured for some time, collateral lymphatics are opened up, or developed, leading into the right innominate vein.

VII. "On the Composition of Hæmocyanin." By A. B. GRIFFITHS, Ph.D., F.R.S. (Edin.), F.C.S., &c. Communicated by M. FOSTER, Sec. R.S. Received March 16, 1892.

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* MacGillavry, "Zur Anatomie der Leber" ('Wien, Akad. Sitzber.,' vol. 50, Abth. 2, 1865, p. 207).

† Budge, "Ueber die Lymphgefäße der Leber" ('Berichte der K. Sächs. Gesell.,' 1875, p. 161.