A FURTHER PROOF THAT THE GALL BLADDER EVACUATES VIA THE CYSTIC DUCT*

By

W. L. VOEGTLIN, M.D.; H. GREENGARD, M.D.,

and

A. C. IVY, M. D.

CHICAGO, ILLINOIS

THAT the gall bladder in fulfilling its physiological function, evacuates by way of the cystic duct is a concept accepted by the majority of investigators.

Lake (4), Lyon (5) and others have noted a decrease in the size of the cholecystogram following stimulation of the visualized gall bladder and a simultaneous increase in the concentration of iodine in the duodenal contents as drained with the Rehfuss tube in human subjects. In order to determine if these findings were applicable to dogs as well, this work was repeated by us on five dogs with results which agree with those of the forementioned authors (see Table I). Likewise

TABLE I

Showing the decrease in the size of the cholecystogram and coincident increase in iodine in the duodenal drainage after cholecystokinin injection (dog).

		Dog Number				
		1	2	3	4	5
Before Injection	Visualization	Good	Good	Good	Good	None
	Bilirubin mg./100 c.c.		23.5	21.0		4.4
	Iodine mg./c.c.	0.48	Trace	0.77	0.48	0.19
After Injection	Decrease in G-B Shadow	50%	40%	50%	30%	
	Bilirubin mg./100 c.c.		97.3	137.1		82.6
	Iodine mg./c.c.	1.30	3.20	3.33	1.17	0.98

Voegtlin, Greengard and Ivy (7), working on dogs with a permanent fistula of the duodenum, repeatedly have obtained bilirubin and cholesterol values in the duodenal contents, following the stimulation of the gall bladder with cholecystokinin injections, that were several times higher than were the corresponding values ever found in determinations on hepatic bile obtained from normal dogs.

The above data are but a small part of the strong presumptive evidence (1) tending to prove the correctness of the assumption that the gall bladder normally evacuates its contents by way of the cystic duct. A small group of observers, however, persist in their opposition to this view. Sweet (6) has suggested that a decrease in the size of the cholecystogram is accomplished by a process of absorption of the dye by the gall bladder wall, and that the increased concentration of iodine in the duodenal contents after stimulation of the visualized gall bladder is due to a re-excretion of this absorbed dye in the hepatic bile. Sweet further maintains that all constituents of the gall bladder bile find their way to the duodenum, not by way of the cystic duct, but by a process of absorption and re-excretion in hepatic bile. Further evidence supporting his theory is the fact that most of the dye injected into an animal may eventually be recovered from a rubber bag connected to a single hepatic duct.

A consideration of the entero-hepatic circulation of tetraiodophenolphthalein offers a ready explanation of this phenomenon. Evidence has been brought forward by Johnston (2) to show that the absorption of tetraiodophenolphthalein from the gall bladder is a slow process although the question never has been investigated under the conditions of Sweet's experiment. The crucial test of Sweet's theory of gall bladder evacuation rests on whether there is an actual increase in the concentration of bilirubin, cholesterol or iodine (if tetraiodophenolphthalein is used) in the hepatic bile stream during active evacuation of the gall bladder.

TABLE II

Showing the concentration of iodine in the gall bladder 16 hours after the injection of the dye into dogs.

Dog Number	Iodine mg./c.c.
1	6.9
2	2.8
3	2.1
4	4.7
5	5.5
6	3.4
7	3.8
8	6.9
9	2.6
10	4.0
11	6.9
12	2.0
Average	4.3

METHODS

Six dogs were operated and run as "acute" experiments under barbital-ether anesthesia. The dogs were set up (sixteen hours after injecting the dye when tetraiodophenolphthalein was used) with a cannula in the common bile duct and another in the hepatic duct draining the right lobe of the liver. (In the dog,

*From the Department of Physiology and Pharmacology, Northwestern University Medical School.

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the duct draining the right lobe of the liver enters the common bile duct below the entrance of the cystic duct.) Control samples were drawn from each cannula and the animal injected with cholecystokinin. A second sample was withdrawn from each cannula after the injection and all four samples, as well as the gall bladder contents obtained at the end of the experiment, were analyzed for iodine (3), bilirubin or cholesterol as indicated in Table III. Dogs IV, V and VI were fed a fat meal two hours before the operation to ascertain if, as would be expected, the biliary constituents are higher in the common duct than in the hepatic bile stream.

RESULTS

In the first two dogs of Table III, the bile was analyzed for iodine after the injection of tetraiodophenolphthalein. Neither of these dogs showed any increase in the concentration of iodine in the hepatic bile stream during the evacuation of the gall bladder or a cholagogue response to the preparation used as estimated by the rate of flow from the hepatic duct cannula before and after injection. There was in increased iodine concentration in the bile drawn from the common duct cannula after injection as well as an augmentation in the rate of flow. Further, in Dog I the bile obtained from the gall bladder was so extremely viscus that the mere fact of its presence in the common duct cannula

TABLE III

Showing the concentrations found in the hepatic and common bile ducts before and after evacuation of the gall bladder (dog). Dogs 1-3 were starved but received cholecystokinin. Dogs 4-6 were fed fat meal in addition to cholecystokinin.

	Before Injection		After Injection		G.B.
	Hepatic Duct	C.B. Duct	Hepatic Duct	C.B. Duct	
Dog I					
Time (min.)	175	175	135	50	
Volume c.c.	0.95	0.90	0.60	2.0	
Iodine*	0.95	1.40	0.31	5.18	6.93
Dog II					
Time (min.)	30	30	35	35	
Volume c.c.	10.5	1.60	1.20	2.20	
Iodine*	1.66	1.60	1.48	2.36	4.00
Dog III					
Time (min.)	50	50	30	10	
Volume c.c.	0.28	0.40	0.30	1.10	
Bilirubin†	126.0	119.0	105.1	228.1	233.0
Dog IV (fat meal)					
Time (min.)	10	10	20	3	
Volume c.c.	0.28	2.8	0.26	2.9	
Bilirubin	85.3	210.0	42.0	256.0	325.7
Dog V (fat meal)					
Time (min.)	20	20	20	3	
Volume c.c.	1.0	2.1	1.1	5.8	§
Bilirubin	50.5	225.4	52.0	482.9	
Cholesterol‡	18.4	72.8	21.0	121.6	
Dog VI (fat meal)					
Time (min.)	20	20	17	3	
Volume c.c.	0.2	2.3	0.25	1.5	
Bilirubin	88.5	238.0	91.5	322.3	448.6

*Iodine reported as milligrams per c.c.
†Bilirubin reported as milligrams per 100 c.c.
‡Cholesterol reported as milligrams per 100 c.c.
§This gall bladder had evacuated so completely after the injection of cholecystokinin that an accurate comparative analysis of the bile constituents could not be made.

constituted a striking tribute to the contractile power of the gall bladder. In Dog III in which the bile was analyzed for pigment alone the same results in general are tabulated. In the three animals which were fed a fat meal (Dogs IV, V and VI), however, the common duct bile was found to be much richer in biliary constituents (pigment and cholesterol) than the hepatic bile collected from the hepatic duct during the same period. The subsequent injection of cholecystokinin enriched the common duct bile still more, indicating that even under the stimulus of a fat meal (given two hours previous to the barbital anesthesia) the gall bladder does not manifest its maximum activity over a prolonged period of contraction. The bile drained from the hepatic duct was not enriched in bilirubin or cholesterol nor was the rate of flow appreciably accelerated following cholecystokinin injection. In Dog V the gall bladder had evacuated so completely after the cholecystokinin that an accurate analysis of the concentrated residue could not be made.

At least Dogs IV, V and VI have demonstrated that in the barbitalized animal during digestion there is no evidence to support the theory that gall bladder constituents are excreted in the hepatic bile and conversely leaves no explanation for the presence of higher pigment and cholesterol values in the common duct as compared with the hepatic duct unless the logical assumption is accepted that the gall bladder is slowly evacuating its contents *via* the cystic duct under the stimulus of the fat meal. Cannulation of the common bile duct also has eliminated the "milking action" of the duodenal peristalses which is of considerable importance in the evacuation of the gall bladder according to some authorities.

Experiments on more dogs were not performed because the results on the five dogs used are so striking and so readily predictable from the almost overwhelming evidence (1) in the literature that the gall bladder evacuates *via* the cystic duct. It would appear to be absolutely established that the gall bladder of man and all animals that possess a gall bladder empties *via* the cystic duct under normal conditions. At least it is believed that those who insist that the gall bladder does not so empty, have no uncontroverted evidence on which to base their claims.

Although some data have been reported on the concentration of bromine necessary to cause visualization of the gall bladder, no reports are at present available on the concentration of iodine in the visualized gall bladder of either humans or animals (1). Concentrations of iodine indicated in Table II were found in a series of 12 dogs following satisfactory visualization of the gall bladder.

CONCLUSION

The only conceivable routes by which the contents of the gall bladder may reach the common bile duct to give the results observed in this experiment are: (a) by way of the cystic duct, or (b) as Sweet suggests, by absorption from the gall bladder and re-excretion by way of the hepatic bile. It has been shown that in barbitalized dogs, the latter mechanism does not occur during evacuation of the gall bladder either by the stimulus of cholecystokinin or a fat meal. The only logical conclusion is that the gall bladder evacuates its contents by the former method: namely *via* the cystic duct.

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