MEASUREMENT AND RECORDING OF TONE OF THE TERMINAL APPARATUS OF THE COMMON BILE DUCT IN CHRONIC EXPERIMENTS ON DOGS

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The terminal apparatus of the common bile duct plays an important part in the liberation of bile into the duodenum and in its accumulation in the gall bladder. It consists of the sphincter of Oddi in the duodenal papilla, and the sphincter of the intramural portion of the common bile duct (sphincter of Boiden). Some investigators regard the muscular sphincters as independent structures [2], whereas others regard the sphincter of Boiden as an integral part of the sphincter of Oddi [1, 5, 6]. Nevertheless, the two structures perform the same function. The resistance of the sphincter of the papillary portion of the common bile duct represents 1/3-1/6 of the total resistance of the whole terminal apparatus of the common bile duct; the remaining resistance is in the sphincter of the intramural portion of the duct.

A study of the function of the terminal apparatus of the common bile duct is usually carried out by X-rays or by manometric determination of the tonic tension. The last method has many advantages, but some shortcomings as well. Its chief merit is that measurement of the tone of the sphincter is not confined to one moment, but enables changes to be recorded on a kymograph. However, such investigations on animals have until now been carried out in acute experiments.

We have set out to develop a method for determination of the tone of the terminal apparatus of the common bile duct in chronic experiments on dogs, and have made use of the principle of direct manometry.

The apparatus was assembled from widely used laboratory apparatus comprising a water manometer, an ultrathermostat, and a universal stand (it is better to employ the stand of the apparatus for measurement of the venous pressure), a kymograph, and a Marey's capsule. The single-limbed glass water manometer was enclosed in a closed glass vessel (the case of an ordinary water condenser) which was connected by 2 rubber tubes to the ultrathermostat. By continuous circulation of water around the manometer the physiological saline within it was maintained at a constant temperature of 38°. The lower end of the manometer was connected by means of a rubber tube to the cannula of the fistula of the gall bladder. The universal stand served to support the manometer in the vertical position and to determine the zero mark of the manometer at the level of the gall bladder. For graphical recording of the changes in tone of the sphincters of the distal portion of the common bile duct a Marey's capsule was connected to the system (Fig. 1).

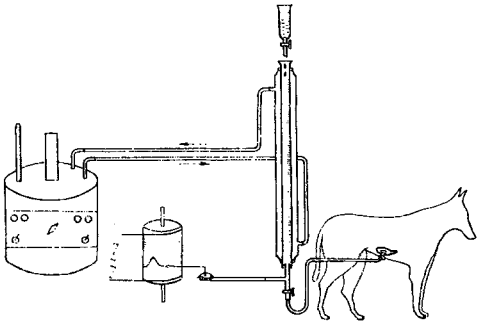

Fig. 1. Diagram of the device for determination and recording of the tone of the terminal apparatus of the common bile duct.

For the prophylaxis of cholecystitis and cholangitis before the commencement of each experiment the manometer and system of rubber tubes were sterilized by careful washing with alcohol or by pouring in disinfectant overnight. Directly before the experiment

Results of the Experiment

Before injection of aminasin		After injection of aminasin	
Time of experiment	filling pressure / Residual pressure	Time of experiment	filling pressure / residual pressure
	In mm water		In mm water
12 hrs 10 min	160 / 140	12 hrs 38 min	200 / 172
12 » 12 »	220 / 200	12 » 39 »	/ 148
12 » 13 »	/ 184	12 » 40 »	/ 130
12 » 14 »	/ 176	12 » 41 »	/ 114
12 » 15 »	/ 162	12 » 42 »	/ 106
12 » 16 »	/ 153	12 » 43 »	/ 100
12 » 17 »	/ 146	12 » 44 »	/ 100
12 » 18 »	/ 140	12 » 45 »	/ 94
12 » 19 »	/ 140	12 » 46 »	/ 94
12 » 22 »	220 / 190	12 » 53 »	160 / 130
12 » 23 »	/ 170	12 » 54 »	/ 120
12 » 24 »	/ 150	12 « 55 »	/ 108
12 » 25 »	/ 140	12 » 56 »	/ 102
12 » 26 »	/ 140	12 » 57 »	/ 96
		12 » 58 »	/ 90
		12 » 59 »	/ 90
12 » 28 »	200 / 170	13 » 08 »	170 / 164
12 » 29 »	/ 160	13 » 09 »	/ 154
12 » 30 »	/ 150	13 » 10 »	/ 150
12 » 31 »	/ 150	13 » 11 »	/ 144
12 » 32 »	/ 150	13 » 12 »	/ 138
		13 » 13 »	/ 132
		13 » 14 »	/ 130
		13 » 15 »	/ 126
		13 » 16 »	/ 126
		13 » 22 »	180 / 170
		13 » 23 »	/ 156
		13 » 24 »	/ 150
		13 » 25 »	/ 144
		13 » 26 »	/ 140
		13 » 27 »	/ 140
		13 » 28 »	/ 140

the disinfectant was removed and the system washed with sterile physiological saline.

Usually 3-4 weeks before the start of the experiment an operation was performed on the dogs to establish a fistula of the gall bladder using Schiff's method, i.e., the common bile duct was not ligated. In between experiments the cannula was closed with a plug to prevent loss of bile and any associated disturbance of function to other organs and systems.

Usually the manometer and the tubes leading from it were filled with physiological saline up to the zero mark and the zero mark on the manometer was brought to the level of the animal's gall bladder. Then the plug of the cannula into the gall bladder was opened and into its aperture was carefully fixed and placed a glass or ebonite cannula connected to the rubber tube of the manometer. Then the manometer was gradually filled with the same solution through its free upper aperture and the pressure of filling was increased each time by 20-100 mm mercury until the level was reached which if exceeded caused opening of the sphincters of the terminal apparatus of the bile duct and the escape of some of the solution into the intestine (escape pressure). The pressure of the solution remaining in the manometer then indicated the so-called residual pressure. Each new single elevation of pressure in the manometer by 20 - 50 - 100 mm mercury was as a rule associated with the escape of fluid into the intestine, and, naturally, by a reduction of pressure to the original level. Thus, under these conditions the residual pressure was of constant magnitude. It represents the tonic tension of the terminal apparatus of the common bile duct. It is true that during the passage of the perfusion fluid from the recording system to the terminal sphincter two structures are encountered whose ability to undergo active contraction may exert some influence on the residual pressure. These 2 structures are the gall bladder and the contractile portion of the gall duct (sphincter of Lyutkens). However, the influence of contractions and relaxations of the gall bladder were greatly reduced by removal of a portion of it during the operation. In addition, according to the claims of many authors [2, 4], the tonic tension of the gall bladder in the fasting condition

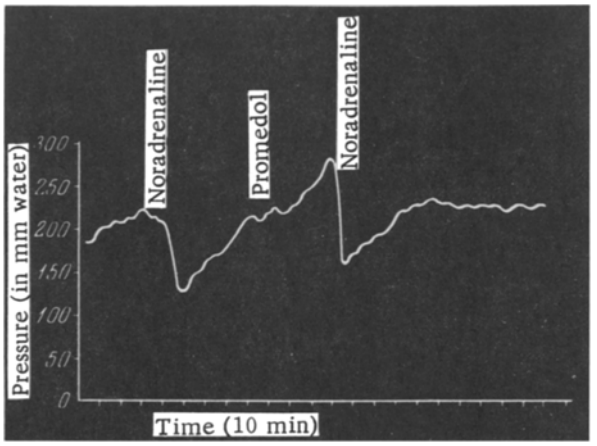

Fig. 2. Influence of 0.5 ml of 1:1,000 noradrenaline and of 1 ml of a 2% solution of promedol on the tone of the terminal apparatus of the common canine bile duct.

is usually very small and increases markedly only during the first hours of digestion. As our control experiments and the physiological observations of E. D. Buglov [1] showed, when the experiments are conducted on an empty stomach the effect of the sphincter of Lyutkens is not appreciable. We may, therefore, suppose that the residual pressure when no digestion is taking place represents an index of the tone of the terminal apparatus of the common bile duct.

Numerous control experiments carried out with this device convinced us that determination of the tone of the sphincters of the distal portion of the common bile duct can be achieved in chronic experiments. A very important condition determining the accuracy of the results is the introduction of physiological saline at a constant temperature of 38° into the biliary apparatus. Any cooling of the solution leads to the development of a spasm, and an increase of temperature causes relaxation of the sphincters. Therefore, the whole system must be filled with a warm solution, and the portion of the rubber tubing between the manometer and the cannula must be enclosed in a further vessel with circulating water at 38°, or else must be covered with an effective thermal insulator.

Measurement and recording of changes in the tone of the common bile duct by means of this method may be carried out many times for several hours. From the results of the different measurements of the residual pressure changes in tone may be deduced.

Besides single or multiple determinations (recordings) of the tone, continuous determination is also possible. For this purpose, after determination of the initial tone a dropper must be included also filled with sterile isotonic sodium chloride solution. The dropper is required in order to ensure that the amount of fluid flowing from it per min lies between 1.0 and 1.5 ml (10-15 mm water).

As a rule, connection of the dropper has the effect that the tone of the terminal apparatus of the bile duct increases: in certain dogs the change was very small, while in others it was appreciable. Nevertheless, when the norm has been recorded for 30-60 min, a change can be made to the main aims of the experiment without any change in the apparatus.

This addition was essential in experiments during which the tone of the terminal apparatus was increased under certain influences, or when it had recovered after a previous fall.

Control and special experiments carried out with the addition of various drugs exerting a marked influence on smooth musculature (pituitrin, morphine, promedol, aminasin, choline, carbocholine, adrenaline, noradrenaline, atropine, etc.), demonstrated the high sensitivity of this method. A study of the changes in tone of the sphincters of the distal end of the bile duct can be made according to the requirements of the experimenter; the records the indications of the manometer at various intervals of time by making a graphical record on the kymograph, or by using both means simultaneously. In the latter case there is no need for interpretation of the kymogram.

As an illustration we give the results of 2 experiments. In the first experiment on the change of residual pressure we studied the character and duration of the action of aminasin on the tone of the terminal apparatus. For this purpose every 15 min we determined simultaneously the tonic pressure before and after intravenous injection of 1 ml of 1% aminasin solution.

Experiment of 23/I/1962. Dog Pirate, weight 20.3 kg. Experiment started at 12.10 h, and terminated at 13.28 h; duration 1 h 18 min. Object of the experiment—determination of the nature and duration of the action of 1 ml of 1% intravenous aminasin on the tone of the sphincter of the distal portion of the common bile duct.

It can be seen from the table that the original residual pressure (i.e., before the injection of aminasin) did not exceed 140-150 mm water. After injection of aminasin it fell to 90 mm water, i.e., by more than $1\frac{1}{2}$ times. The The residual pressure remained depressed for 45 min.

From the results of this experiment, and from many similar observations we have concluded that aminasin exerts a marked cholespasmolytic action. This effect often appears during experimental hypertonia of the terminal apparatus evoked by carbocholine, morphine, promedol, or other drugs.

Another dog received 0.5 ml of a 1:1,000 solution of noradrenaline bitartrate before and after injection of promedol, which was used to enhance the tone of the biliary sphincters. We made a long-term recording of the tone of the terminal apparatus on a kymograph. Throughout the experiment the dropper was included. The results of this experiment are shown in the kymogram of Fig. 2. Here, as in the previous experiment, there was a marked reduction in the tone of the sphincters, and it was superimposed upon a hypertonia of the sphincters evoked by promedol.

This method of determination and recording the tone of the terminal apparatus of the common bile duct may have wide applications in pharmacology for the study of the effect of drugs on biliary tone. Also, it may be found useful in studying many problems of the physiology and pathology of biliary secretion.

SUMMARY

A new method incorporating direct manometry was developed for measurement and recording of the tone of the terminal apparatus of the common bile duct. Three to four weeks before the start of these experiments a permanent fistula was established in the bile duct without ligation of the common bile duct. The change of tone of the sphincter of the common bile duct was recorded in terms of the residual pressure. The observer could assess the changes either by taking note of the manometer readings, or by making a kymograph record.

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All abbreviations of periodicals in the above bibliography are letter-by-letter transliterations of the abbreviations as given in the original Russian journal. *Some or all of this periodical literature may well be available in English translation.* A complete list of the cover-to-cover English translations appears at the back of this issue.
