QUANTITATIVE EVALUATION OF FILLING AND CONTRACTILE POWER OF THE GALL BLADDER

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Correlation between the length and the greatest diameter of the gall bladder is weak except during digestion. The use of these parameters to determine the volume of its contents gives distorted results. A method of studying rhythmic fluctuations of the gall bladder is suggested, by means of which changes taking place in the complete outline of the gall bladder on the roentgenogram can be studied visually.

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The contractile power of the gall bladder can be estimated quantitatively from its shadow on roentgenograms by using the method suggested by Sieffert [7]. Simpler but less accurate methods are also available [2-6]. Some methods of determining the volume of the gall bladder [5, 6] are based on measurement of the greatest diameter and length of its shadow on the roentgenogram, although correlation between these parameters has not been studied [6]. In the course of a single experiment, while the greatest values of the transverse diameter and length of the gall bladder remained the same, its volume calculated by Sieffert's method varied [1].

To study correlation between the length and greatest width of the gall bladder, a mathematical analysis was made of roentgenologic data obtained during filling and emptying of the gall bladder. A special series of experiments was carried out in which rhythmic contractions of the gall bladder were studied at times other than during digestion.

EXPERIMENTAL METHOD

The experimental method has been fully described previously [1]. To study correlation between the length and greatest width of the gall bladder during filling, 398 roentgenograms of 50 dogs were taken. The length and the greatest diameter were measured on each roentgenogram. Dimensions of gall bladders on roentgenograms taken 45 min after injection of contrast material were taken for mathematical analysis.

Correlation between the length and the greatest diameter of the gall bladder during emptying were studied in 30 dogs. Roentgenograms taken 10 min after the beginning of emptying were analyzed.

To study the stage of the gall bladder outside the period of digestion, after a meal the evening before the experiment the dog was given 5 g bilitrast with milk. An intraveneous injection of 3 ml bilignost (iodipamide) was given 18 h later, and the first roentgenogram taken after a further 90 min. According to the literature [4], the size of the gall bladder increases to a maximum 60 min after injection of bilignost. The time interval from 90 to 165 min was chosen for investigation, and during this period 5 roentgenograms were taken at intervals of 1, 3, 5, and 30 min. In this way the gall bladder, filled with contrast material, could be observed for 75 min in the absence of digestion. The volume of the contents of the gall bladder on each roentgenogram was calculated by Sieffert's method, and the length and greatest diameter of the gall bladder were measured. The experiments were carried out on 10 dogs, and 146 roentgenograms were used for mathematical analysis.

EXPERIMENTAL RESULTS

Correlation between the length and the greatest diameter of the gall bladder during filling with contrast material is weak, because the increase in volume of bile containing the dye is accompanied by changes

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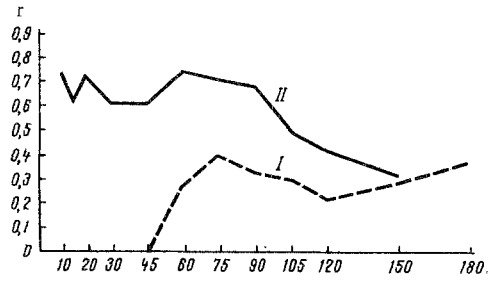

Fig. 1. Correlation between length and greatest diameter of the gall bladder during filling (I) and emptying (II). Abscissa: time after injection of contrast material; ordinate: coefficient of correlation.

Fig. 2. Correlation between length and greatest diameter of gall bladder outside digestion. Abscissa: serial no. of roentgenogram; ordinate: coefficient of correlation.

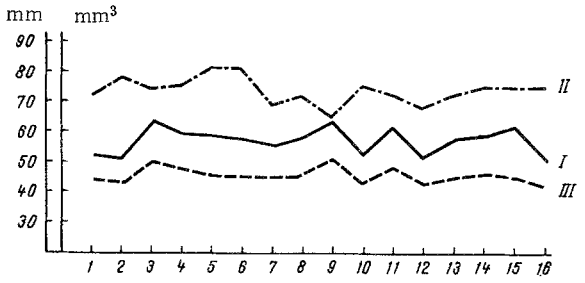

Fig. 3. Changes in volume (I), length (II), and diameter (III) of gall bladder outside digestion. Abscissa: serial no. of roentgenogram; ordinate: volume of gall bladder (in mm^3) and diameter (in mm).

affecting predominantly one parameter. The coefficient of correlation between the two parameters after 60 min was 0.28, after 75 min 0.4, and after 180 min 0.36 (Fig. 1). However, after taking food, correlation between these parameters until 90 min after the beginning of emptying of the gall bladder was strong, varying from 0.73 to 0.61 (Fig. 1). During this period contraction of the gall bladder affects both parameters uniformly. After 105 min, when the gall bladder was emptied by more than 50%, correlation between the length and greatest diameter fell, to reach 0.31 after 150 min. The change in volume of the gall bladder during this period was associated with a change in predominantly one parameter. Correlation between the length and greatest diameter of the gall bladder in the absence of digestion was very close to the correlation between these parameters during filling and in the late stages of emptying of the gall bladder (Fig. 2). Outside digestion, during rhythmic contractions of the gall bladder, changes in its diameter accurately reflected changes in its volume (Fig. 3).

To determine what changes take place in the outlines of the gall bladder at short time intervals (1, 3, 5 min) the following method was used. A grid with a distance of 3 mm between the lines was placed above the shadow of the gall bladder on the roentgenogram. The diameter of the gall bladder shadow was measured at the level of each line. The size of the shadow on the first roentgenogram (90 min after injection of bilignost) was used as the standard of comparison for subsequent films. To demonstrate clearly changes taking place in the length and diameter of the gall bladder, the results were plotted on squared paper. A vertical line was drawn to represent the zero line. The difference (in millimeters) between the original shadow of the gall bladder and its shadow on a subsequent film were shown by points near the vertical straight line. Points reflecting an increase in size (+) of the gall bladder shadow in a particular area were plotted on the right, points reflecting a decrease (-) on the left. The points were then joined in succession by a smooth curve reflecting changes in the shadow of the gall bladder relative to the original roentgenogram. The sum (in millimeters) of the deviations of the gall bladder diameter to the right and left of the vertical line was calculated. It was concluded from the results obtained that rhythmic contractions of the gall bladder occur in waves over the whole of its outline. This explains the particularly close correlation between the volume of the gall bladder and its length and greatest diameter. It is clear that formulas for determining the volume of the gall bladder using these parameters [5, 6] do not reflect true fluctuations in the volume of the gall bladder. Peristaltic waves running along the whole length of the gall bladder change its volume through the contraction or dilatation of individual segments of the organ, without modifying its greatest diameter.

The suggested graphic method of analysis of movements of the gall bladder can be used to determine the state of any of its segments at a given moment and to estimate either the total change in volume of the gall bladder or the tendency for any part of it to contract or dilate.

LITERATURE CITED

1. P. K. Klimov, Mechanisms of Regulation of Functions of the Biliary System. Author's Doctoral Dissertation, Leningrad (1967).
2. L. D. Lindenbraten and I. O. Kruglyakov, Ter. Arkh., No. 8, 68 (1961).
3. L. D. Lindenbraten and I. O. Kruglyakov, in: Introduction of Some New Methods of Diagnosis, Treatment, and Prophylaxis of the More Important Diseases into Practice [in Russian], Moscow (1961), p. 61.
4. L. D. Lindenbraten, I. O. Kruglyakov, B. M. Astapov, et al., in: Roentgenophysiology and Functional Pathology of the Gall Bladder [in Russian], Moscow (1965), p. 199.
5. I. S. Petrova, in: Proceedings of the 3rd Zaporozh'e Inter-Regional Scientific and Practical Conference to Commemorate the 70th Anniversary of the Discovery of X-Rays [in Russian], Zaporozh'e (1966), p. 148.
6. E. Z. Polyak, in: Roentgenophysiology and Functional Pathology of the Gall Bladder [in Russian], Moscow (1965), p. 222.
7. G. S. De Paula e Silva, Radiology, 52, 94 (1949).