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Original Research Article.

Ultrasonographic Study of Kinetics of Gallbladder Contraction According to Food Intake

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ABSTRACT

The aim of the present study was to elucidate one aspect of the physiological function of gallbladder by examining the kinetics of contraction after intake of low or high-calorie food. As a preliminary study, ten healthy male adults were fasted for 24 hours, and the gallbladders were examined using an abdominal ultrasound. The gallbladder had the smallest area at 8:00 hours and then shows gradual relaxation. From 12:00 to 18:00 hours was plateau. Based on these results, we conducted the study between 12:00 and 18:00 hours. In the low-calorie (270kcal) intake group (n=31), food intake caused very little contraction of the gallbladder. In the high-calorie (673 kcal) intake group (n=31), marked contraction was observed 2 hours after food intake and was followed by gradual relaxation. Low-calorie food intake group was very little contraction of the gallbladder. Therefore, it seems not so strong influence on physiological function of gallbladder.

Keywords: Ultrasound, Gallbladder Contraction, Fasting, Low-Calorie, High-Calorie.

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INTRODUCTION

The gallbladder is known to contract by egg yolk administration. This phenomenon is utilized as one aspect to examine the contracting function of the gallbladder by excretory cholecystography. However, the kinetics of gallbladder contraction according to food intake is rarely reported. Recently, 3.5 MHz ultrasonography is generally used for morphological study of the gallbladder, and fasting is generally required before this examination.

However, we hypothesized that intake of a low-calorie meal may not necessarily affect gallbladder contraction. The aim of the present study was to elucidate one aspect of the physiological function of gallbladder by examining the kinetics of contraction after intake of low or high-calorie food.

MATERIALS AND METHODS

Preliminary Study: A preliminary study was conducted to examine the diurnal changes of the gallbladder under 24-hour fasting. Ten healthy male adults (average age: 38.5 years) were fasted for 24 hours, and the gallbladders were examined at 8:00, 10:00, 12:00, 14:00, 16:00, 18:00 and 20:00 hours using an abdominal ultrasonographic device (transducer 3.5 MHz). The subjects were allowed to drink water and to read books or watch television freely as if at home. Based on the right sub-costal arch scan, right intercostal scan and right superior abdominal longitudinal scan, the image showing the greatest gallbladder diameter was used in analysis.

Effect of Food Intake: The study proper consisted of two groups taking low and high calorie foods as shown in Table 1.

(a) In the low-calorie intake group, the subjects (n=31, mean age; 38.5 + 7.5 year) fasted from the morning and took low-calorie food (Udon; Japanese wheat noodle) at 12:00 hours. The gallbladder was imaged before eating, after eating and 2, 4 and 6 hours afterwards.

(b) In the high-calorie intake group, the subjects (n=31, mean age; 38.5 + 7.5 year) fasted from the morning and took high-calorie food (Katsudon; fried pork on rice) at 12:00 hours. The gallbladder was imaged before eating, after eating and 2, 4 and 6 hours afterwards.

(3) Image recording and determination of gallbladder area: The ultrasonographic images were recorded on thermal paper. The gallbladder area was determined by scanning the thermal paper record as 2-tone images and analyzed as NIH images.

(4) Rate of gallbladder contraction

The maximum gallbladder area during fasting was designated A (cm^2) and the gallbladder at each time point after food intake as B (cm^2). The contraction rate was calculated as (1-B/A)X 100%

Table 1: Nutritional composition of the low and high-calorie foods used in the study.

	Energy (kcal)	Protein (g)	Fat (g)	Sugar(g)
Low-calorie intake	270	6.0	1.0	59.2
High-calorie intake	673	23.7	19.2	106.7

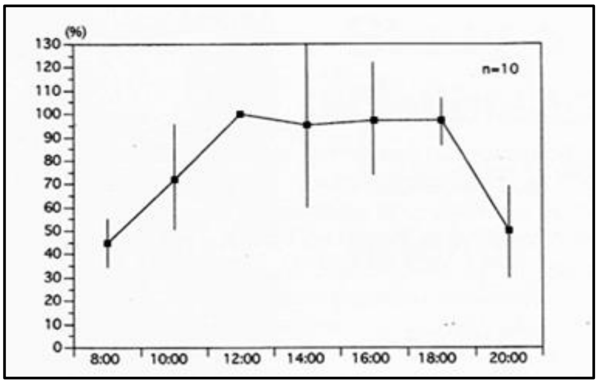

Fig 1: Kinetic Motion of the Gallbladder in Fastin

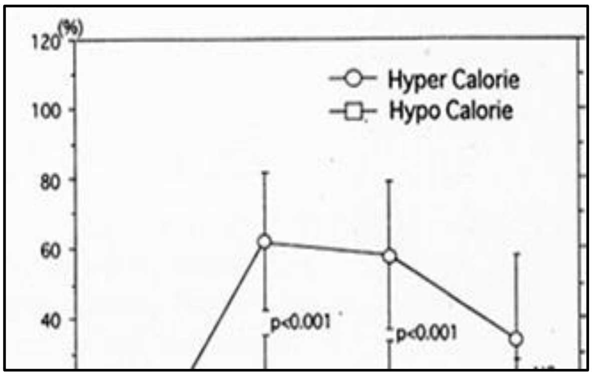

Fig 2: Contraction Rate of the Gallbladder

RESULTS

(1) Preliminary Study (Diurnal Changes of the Gallbladder): The gallbladder areas of healthy subjects (fasting) were 3.55+0.93 cm2 at 8: hours, 5.96 +1.95cm^2 at 10.00 hours, 7.89+1.41cm^2 at 12:00 hours, 7.53+2.72 at 14:00 hours, 7.69+1.86 cm^2 at 16:00 hours, 7.69+0.84 cm^2 at 18:00 hours and 3.94+1.50 cm^2 at 20:00 hours. Taking the area at 12:00 as 100%, gallbladder area was 45.0+11.9% at 8:00 hours, 72.1+24.9% at 10:00 hours, 100%at 12:00 hours, 95.5+35.6 at 14:00 hours, 97.5+23.7% at 16:00 hours, 97.5+10.5% at 18:00 hours and 50.0+19.7 cm^2 at 20:00 hours (Fig.1). The gallbladder had the smallest area at 8:00 hours and then shows gradual relaxation. The relaxation reached almost a plateau from 12:00 to 18;00 hours, but contraction was again observed at 20:00 hours. Based on these results, we conducted the study between 12:00 and 18:00 during which the gallbladder area is at a plateau in terms of diurnal changes.

(2) Study Proper (Effect of Food Intake): Table 2 and Figure 2 show the results of the changes in kinetics of gallbladder contraction according to food intake.

In the low-calorie intake group, food intake caused very little contraction of the gallbladder. In the high-calorie intake group, marked contraction was observed 2 hour after food intake, and was followed by gradual relaxation. Figure 3 shows the kinetics of gallbladder contraction in representative cases of low-calorie and high-calorie food intake.

Table 2: Changes of gallbladder contraction rate according to food intake.

	Fasting 2 hr after meal	4 hr after meal	6 hr after meal
Low-calorie intake	20+14.9	20.6+12.4	15.8+12.3
High-calorie intake	62.0+19.7	58.1+21.2	23.6+24.7

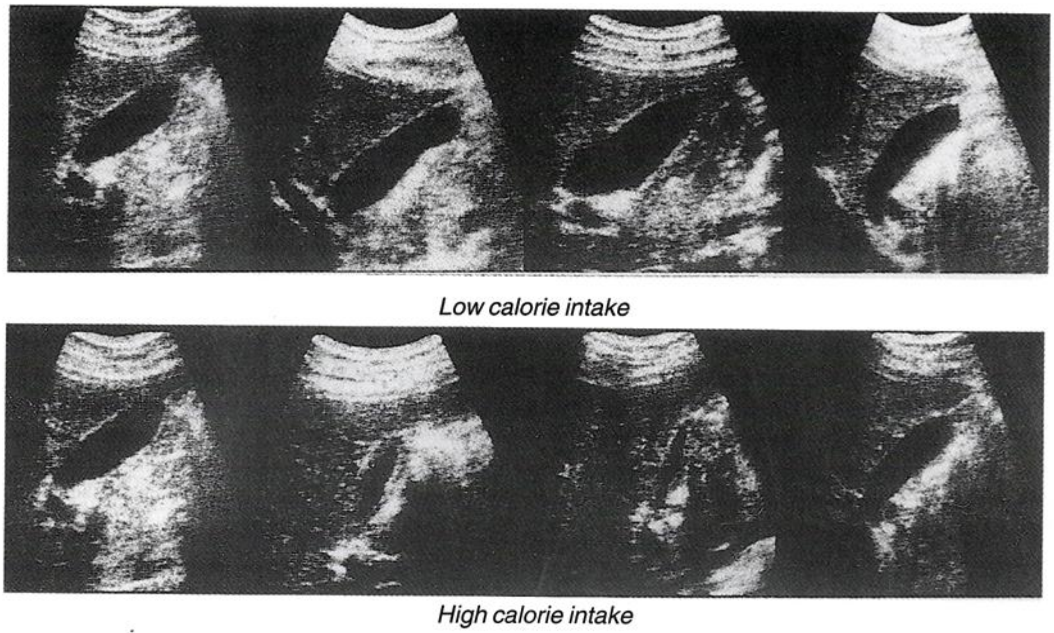

Fig 3: The kinetics gall bladder contraction in representative cases.

DISCUSSION

The gallbladder function is associated with the sympathetic nerves. Under normal condition, the gallbladder and the sphincter of Oddi exhibit coordinated movements controlled by mutually antagonistic actions of the sympathetic and parasympathetic nerves. In general, when the parasympathetic nerve (vague nerve) is in an excited state, the excitability state of the whole biliary system is increased, and gallbladder contraction is strong. On the other hand, in states of unbalance such as increased sympathetic nerve (splanchnic nerves) activity or parasympathetic nerve palsy, the overall excitability of the whole biliary system is decreased and the gallbladder relaxes. However, even when the vagus nerve splanchnic nerve are both dissected, administration of cholecystokinin (CCK) induces contraction of the gallbladder and relaxation of the sphincter of Oddi. Therefore, the biliary function is not only subjected to nervous control but is also associated with humoral regulatory factors. While it is an in irrefutable fact that CCK induces gallbladder contraction, gastrin is also known to exhibit a gallbladder contracting effect, but the action is only 1/22 that of CCK.[1]

Recently, many new gastrointestinal hormones have been discovered. Among them, vasoactive intestinal polypeptide (VIP), somatostatin and gastrin releasing peptide (GRP) are known to be nerve peptides that are found in the nerve plexus located in the intestinal wall and have also been shown to be present in the nerve fibers in the biliary system.[2]

Sundler[3] reported that VIP exists in the smooth muscle layer of the human gallbladder, and that VIP suppresses contraction through CCK stimulation.

There is almost no dispute that VIP a nerve peptide antagonizes CCK-induced gallbladder contraction. As of present, CCK and VIP have been reported as the two intestinal hormones associated with movement of biliary tract. Further research is required to elucidate the actions of other intestinal hormones. Therefore, studies so far have revealed that in gallbladder contraction, although the splanchnic nerve exerts an inhibitory action while the vagus nerve plays an enhancing role, the intestinal hormones coordinate these actions. Together, they form the mechanism of the physiological gallbladder motion. The observation that the gallbladder shows contraction and relaxation even under fasting condition may be due to complicated interactions of these factors. For example, the subjects were allowed to watch television freely and they might have watched cooking or other programs on food, which induced CCK secretion resulting in gallbladder contraction. On the other hand, VIP acted antagonistically and might have caused gallbladder relaxation. In another situation prolonged fasting might put a subject into a state of mental stress. The vagus nerve might dominate to cause gallbladder contraction, only to be followed by the antagonistic action of the splanchnic nerve. Therefore the gallbladder is not only influenced by food intake, and these neurohormonal factors also have to be considered. From the diurnal changes observed during fasting, the gallbladder is contracted in the morning, and relaxes gradually to reach a plateaued size from 12:00. This may also be a physiological movement of the gallbladder. Therefore, we performed the study from 12:00 hours.

As also reported by Siegel[4] ultrasonographic technique is the most suitable method for observing gallbladder function. In the present study, the ultrasonographic observations were conducted by experienced doctors and technicians. Egg yolk or CCK injection is used conventionally to observe gallbladder function, but Ho et at.[5] examined gallbladder contraction by ultrasound B mode observation after milk drinking. Nitsche et al.[6] reported that 330ml of cacao drink is suitable to observe gallbladder contraction in patients with gallstones. Boeka et at.[7] reported that coffee is suitable for observing gallbladder contraction. We compared the degree of contraction in subjects who took a low-calorie meal and in those who consumed a high-calorie meal. We observed a new finding that food intake does not necessarily affect gallbladder contraction if the caloric level is 270 kcal or below. This finding may contribute to understanding of one aspect of physiological function of the gallbladder.

CONCLUSION

Low-calorie food intake (279 kcal of lower) caused very little contraction of the gallbladder. Therefore it seems not so strong influence on physiological function of gallbladder.

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