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Application of pulsed Doppler ultrasound for the evaluation of small intestinal motility in dogs

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The purpose of this study was to verify whether small intestinal peristalsis could be observed and quantitatively assessed using pulsed-Doppler ultrasound. Pulsed-Doppler ultrasound was used to evaluate small intestinal peristalsis after a meal in ten normal dogs and ten sedated dogs. The small intestinal peristalses were measured 0, 1, 3, 6, 9, 12, and 24 hours after a 24-hour fast and after feeding. The number of small intestinal peristalsis were 0.133/min, 0.100/min, 0.033/min, 0.167/min, 0.070/min, 0.067/min, and 0.100/min in the fasted dogs, and 1.667/min, 0.933/min, 1.133/min, 1.234/min, 1.933/min, 1.533/min, and 0.533/min in fed dogs, respectively. In the dogs sedated with xylazine HCl, the number of small intestinal peristalsis was significantly reduced ($p<0.01$). However, in the dogs treated with ketamine HCl and acepromazine, the number of small intestinal peristalsis remained unchanged. Therefore, it can be concluded that pulsed-Doppler ultrasound allows graphic visualization of the intestinal movements, which can be subjected to qualitative and quantitative analysis, and may be suitable for a non-invasive study of small intestinal motility.

Key words: dog, pulsed-Doppler ultrasound, small intestinal peristalsis, feeding, sedation

Introduction

Abdominal ultrasound techniques have been used for evaluating normal small intestinal structure, wall thickness, and peristalsis in vivo or in experimental situations, due to it being ultrasound is biologically non-invasive and needing little patient preparations [2, 7]. In dogs, real-time ultrasound facilitated the observation of their intestinal motility and structure [20].

Gimondo *et al.* [9] classified both peristaltic movement and non-peristaltic movements by measuring small intestinal peristalsis in human patients using pulsed-Doppler ultrasound. In addition, the accuracy of pulsed-Doppler ultrasound was confirmed by comparing the results of small intestinal peristalsis using auscultation and phonocardiography with those using pulsed-Doppler ultrasound [8]. However, applying pulsed-Doppler ultrasound to animal studies has not been reported and generalized in clinical practice.

Intestinal motility is the result of a complex interplay of factors that include cell characteristics, contractile activity, and neurohumoral regulation [30]. However, the understanding of the relationships among these factors and of intestinal motility itself is far from complete. Some of the techniques currently used for investigating in vivo intestinal motility such as electromyography and manometry are thought to yield detailed information. In spite of this, these techniques are unsuitable for large-scale clinical studies due to their complexity [19, 24].

The method of monitoring contractions by placing sensors on the serosal surfaces to evaluate the intestinal motility and transit was also introduced. However, there were numerous difficulties in locating accurate sensor position and achieving reproducibility [23]. Furthermore, auscultations, radiographic examinations, hydrogen breath tests did not provide sufficient and objective information [3, 4]. Investigations using radioactive isotopes placed in the small intestine of animals have been reported and the distribution of isotope within the bowel determined, but this technique was limited due to the need for prior marker implantation and sacrifice of the animals [28].

Studies aimed at clarifying the relationship between the administration of anesthesia and intestinal motility have included xylazine HCl in ponies with electrode implantation, xylazine HCl, atropine, and acepromazine in dogs for gastrointestinal sphincter pressure, and ketamine HCl and other drugs in dogs with radiographic examination and hydrogen breath testing [1, 6, 12, 27]. These previous studies examined human patients or animal models for human

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diseases. However, there is a paucity of studies using Doppler ultrasound in animals. Therefore, the present study was aimed at verifying whether small intestinal peristalsis could be observed and quantitatively assessed by means of pulsed-Doppler ultrasound in dogs in addition to acquiring some fundamental physiologic information so this technique can be introduced into veterinary clinical science.

Materials and Methods

Animals

Twenty clinically healthy adult dogs were used for the sequential intestinal motility evaluation and divided into 2 groups; 10 dogs that were sedated and 10 that were not. All the animals were shown to be clinically healthy through a thorough physical examination, abdominal radiography and real-time ultrasound, and blood and serum chemistry prior to the experiment.

Ultrasound equipment

An SSA260A/CE® (Toshiba, Japan) was used with a 3.75 MHz phased array sector transducer. A pulse repetition frequency of 4.5 kHz and a Doppler gate width of 3 mm were selected. The gain setting was grade 78(62~100) and the depth was fixed at level 4, and the other variables were not changed during the scan. The time gain compensation followed the usual clinical settings.

Sedatives

Two mg/kg xylazine HCl (Rompun®, Bayer Korea, Korea) was administered intramuscularly, and both 10 mg/kg ketamine HCl(Ketalar®, Yuhan Pharmaceuticals, Korea) and 0.03 mg/kg acepromazine(Sedaject®, Samwoo Chemical, Korea) were administered intravenously, respectively.

Measurement

The hair around the scan site was clipped and a sufficient amount of coupling gel was applied for the best visualization. The animals were restrained in the right recumbent position. The transducer was located immediately caudal to left last rib. During the early scanning period, the B-mode was used for locating the optimal bowel loop, and then the mode was switched to the pulsed Doppler mode. The sample volume cursor was located in the small intestinal lumen through the acoustic window of the spleen. The number of peristaltic contractions was recorded three times over a one-minute time period and the average number of contraction was then calculated.

The ultrasound scans were measured at 0, 1, 3, 6, 9, 12, and 24 hour after a 24-hour fast in both the control and fed group. In the group of sedated animals, scanning was done 6 hours after feeding. The peristaltic movement was characterized by a high amplitude with a Doppler shift approaching or greater than 1 and lasting for at least 2 seconds (Fig. 1) [8]. All animals in the fed group were provided commercial dry food.

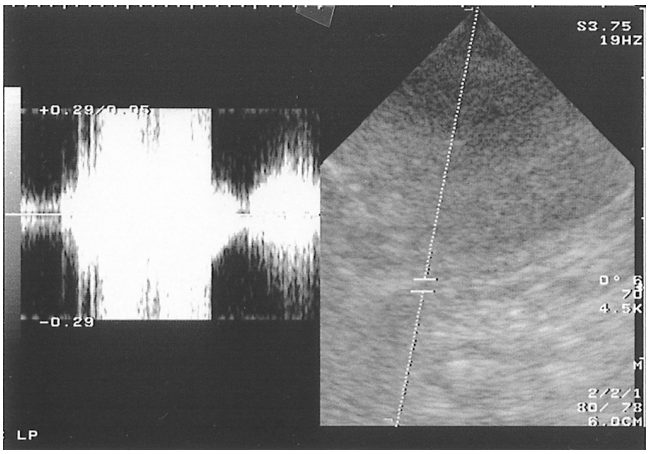

Fig. 1. Duplex Doppler image of normal small intestinal peristalsis in a dog. The peristaltic movement was characterized by a high amplitude with a Doppler shift approaching or greater than 1 kHz and lasting for at least 2 seconds.

Statistics

The results obtained from each group were averaged and compared with the ANOVA test.

Results

Measurement of the peristaltic movement of small intestine in fed dogs

The numbers of peristaltic waves in the small intestine after 24-hour fasting were 0.133/min 0 hour, 0.100/min 1 hour, 0.033/min 3 hours, 0.167/min 6 hours, 0.070/min 9 hours, 0.067/min 12 hours, and 0.100/min 24 hours, respectively. The numbers of peristaltic waves in the small intestine after feeding subsequent to a 24-hour fast were 1.667/min immediately after, 0.933/min 1 hour, 1.133/min 3 hours, 1.234/min 6 hours 1.933/min 9 hours, 1.533/min 12 hours, and 0.533/min 24 hours after feeding. In the comparison between number of peristaltic waves per minute in the small intestine of the two groups; the group after 24-hour fasting (control) and the group that were fed after the 24-hour fast (fed), which shows there was no significant changes among each measurement times. However, excluding the 24-hour time measurement, there were siginficant differences between the control and fed group ($p<0.05$).

Measurement of the peristaltic movement of small intestine in sedated dogs

The numbers of peristaltic waves in the small intestine of the sedated dogs were 0.000/min in xylazine HCl, 0.999/min, in ketamine HCl, and 1.201/min in those dogs administered xylazine HCl, ketamine HCl, and acepro-

mazine administered group, respectively. The number of peristaltic waves in the xylazine HCl treated group was lower than those of the control group($p<0.01$).

Discussion

Several reports on the use of emphasizing the ultrasound for evaluating the gastrointestinal disorders are available [22, 25, 31]. The detailed advantages of pulsed Doppler ultrasound over the other methods such as auscultation and phonocardiography include greater simplicity, faster results, more objectivity, and the ability to discriminate the peristaltic wave from non-peristaltic one [8]. However, in the present study, the non-peristaltic waves were not included in the results, because non-peristaltic waves are defined as a weak signal with an amplitude of less than 1 kHz lasting less than 2 seconds and can be induced by mixing or segmentation movements [8].

Doppler ultrasound has been used for the effective diagnosis of gastrointestinal disorders related to motility. This is because it can detect the movements of the intraluminal contents using the Doppler effect and it has its advantage of reproducibility, real-time observation, high resolution and non-invasiveness [9, 11, 21].

Radiographic techniques, myelography, phonocardiography, hydrogen breath testing, manometry, radioactive isotope, multilumen polyvinyl tube, and scintigraphy have also been introduced in the study of the evaluation of small intestinal motility. However, many difficulties in applying these methods have been reported [5, 10, 13, 15, 29].

Although, the duplex Doppler technique is easy to perform, artifacts caused by deeper respiratory movements of the animal or inadvertent manual pressure may appear. Therefore, Gimondo and Mirk [8] stressed that excessive manual pressure should be avoided because the peristaltic movement may be altered and hampered by the pressure of the transducer applied to the skin during ultrasound scanning. In the present study, all of the animals were scanned in the right recumbent position using the spleen as an acoustic window without any remarkable difficulties. In addition, the authors attempted to apply the transducer as lightly as possible, during the scan. In the case where the gas was present, the sample volume was placed near the anterior wall. This is because the rest of the wall was completely obscured by reverberation artifacts.

Aliasing artifacts were occasionally observed with forceful contractions. However, this phenomenon should not be a significant problem in interpreting the Doppler findings, because these do not occur with weak, low-amplitude signals, and the appearance is merely a confirmation of the strength of the contraction [8]. As Gimondo and Mirk [8] concluded, the standards regarding small intestinal peristalsis are quite limited, and more reliable criteria should be established in future studies based on simultaneous Doppler ultrasound and the other feasible methods.

The peristaltic wave can be described as a ring of constriction that moves aborally over a short segment of the intestine. The migrating motility complex changes from the cyclic pattern seen with the interdigestive migrating motility complex (IDMC) to the fed pattern of the phase 2 contractions after consumption of a meal. The physical and chemical composition of the food determines the length of time before the IDMC pattern returns. Dogs fed milk develop the fed pattern for 2.5 to 4 hours. The type of nutrient is important in that the isocaloric quantity of peptides, glucose, and medium chain triglycerides result in fed patterns of 2.8, 4.8, and 7.5 hours, respectively. In the fasted state, propulsive activity is periodic with intervals of little or no activity lasting for an hour between the propulsive waves [26]. In the present study, almost similar results were obtained. In fasted animals, the number of real peristaltic movements were decreased and in fed group, the number of peristaltic waves immediately increased after feeding with gradual decreases being observed thereafter. However, the precise cause of the unusual increase in the number of peristaltic waves nine hours after feeding is not clearly understood.

Xylazine HCl is a potent α2-adrenergic agonist, which has analgesic and sedative effects. Some studies evaluating intestinal motility after implanting electrodes have shown that intestinal motility is markedly reduced after xylazine HCl administration [1, 16, 18]. In the present experiment, a similar decrease in the peristaltic movements of the small intestine was also found after xylazine administration. Fass et al. [6], studying the relationship between the gastrointestinal motility and ketamine HCl administration with the dose of anesthesia and sedation, reported no remarkable changes in treated group. The results in this study tend to agree with the present study. In addition, there was no siginficant differences reported between the treated and control group in the study that measured the pressure of gastrointestinal sphicters after acepromazine administration [27], which was also confirmed in present study showing no remarkable changes in small intestinal motility.

In conclusion, duplex Doppler sonography has a unique advantage. It can reveal intestinal motility under physiologic conditions, that is, without provoking local stimulation or systemic stress that can affect gastrointestinal motility [14, 17]. Although non-peristaltic waves were not counted in the present study, on the basis of the amplitude and duration of the Doppler signal, peristaltic waves can potentially be distinguished from contractions that are not associated with advancement of the intestinal contents. Therefore, it is believed that duplex Doppler studies are fast, reproducible, and allow graphic visualization of intestinal movements that can be subjected to both qualitative and quantitative analysis.

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