FULL PAPER ***Surgery***

Evaluation of Canine Gastric Motility with Ultrasonography

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ABSTRACT. For the evaluation of canine gastric motility with ultrasonography, contraction number of pyloric antrum and gastric emptying time (GET) by area and volume method developed by Bolondi *et al.*'s method were studied in 14 dogs. All experimental dogs were administered with saline and soup solution (10 m*l*/kg, B.W.). The mean values of contraction number of pyloric antrum in saline and soup group were 4.19 ± 1.30/min and 4.82 ± 0.65/min before feeding, and overall mean values were 4.66 ± 1.37/min and 5.13 ± 1.71/min, respectively. The mean values of the GET by area and volume method were 36.73 ± 11.27, 40.00 ± 8.87 min in saline group and 61.35 ± 17.58, 59.11 ± 14.46 min in soup group. In the GET in saline and soup groups, there was no significant difference between the area and volume method ($p>0.05$). Therefore, Bolondi *et al.*'s method by ultrasound can be used to evaluate the antropyloric motility and gastric emptying time with area and volume methods. The area method is easier to determine the GET than the volume method, but the latter is more accurate.

KEY WORDS: canine, gastric motility, ultrasonography.

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In veterinary clinical medicine, ultrasonographic studies of canine stomach were mainly on the normal and abnormal morphology rather than the functional analysis [1, 3, 20, 21]. But recent technical developments enable one to evaluate gastroduodenal motility by using ultrasonography, which is simple and noninvasive. In human medicine, since Bateman & Whittingham [2] first reported the measurement of gastric emptying by ultrasonography and video tape recording, it also has been possible to observe the movement of pyloric fluid by ultrasonography [8]. Especially, Bolondi *et al.* [4] reported that ultrasound study of the antropyloric region based on measurements of the cross section area of gastric antrum and the volume of the whole antropyloric region allowed accurate determination of total gastric emptying time (GET) in human beings. With this functional analysis of gastric motility with ultrasonography, there were some reports about functional analysis of gastric emptying in human-beings [6, 7, 22]. But there are no report about the GET by ultrasonography in veterinary medicines.

The objectives of this study are to evaluate GET with Bolondi *et al.*'s method with saline solution and test meal (soup) in dogs as well as its repeatability and applicability in functional analysis of canine stomach with ultrasonography.

MATERIALS AND METHODS

Experimental animals: Fourteen mature (1–3 years), clinically healthy mongrel dogs weighing 3.5–10.0 kg were used for this experiments. Seven dogs were alloted in saline group, and the others in soup group. Three to seven days after experiments, all dogs in saline group were alloted in soup group, and vice versa for experiments. Before ultrasonographic examination, all dogs were accustomed to lying on the V-shape positioner.

Test meal feeding: All dogs had been fasted for at least 12 hr with only water *ad libitum*. Prior to performing experiments, 800 mL hot water was used for dissolving 100 g of soup powder (cream soup®, Daesang Food Co., Ltd, Seoul, Korea). So the final concentration of soup solution was 12.5% (w/v). Warm (37°C) saline and soup solution were fed as a dosage of 10 mL/kg, B.W. through a gastric tube. The calories and nutritional components in 100 g of soup were shown in Table 1.

Ultrasonographic investigation: All dogs were supine positioned and hair was clipped and there were no technical errors by contacting the probe with skin using gel. Ultrasound examinations were performed with a high-resolution real-time scanner (Toshiba SSA-260A, Tokyo, Japan) with a 7 MHz sector probe. With the experimental dogs positioned in dorsal recumbency, transverse images were obtained by placing the transducer in a transverse plane of the cranial abdomen, parallel to the right costal arch.

By rotating the transducer 90° in a clockwise direction, longitudinal images were made and the cross sectional area, pylorus-antral canal depth and GET using Bolondi *et al.*'s [4] method were measured. The cross section of the gastric antrum corresponding to the right parasagittal plane presented an elliptical shape, and its area was calculated in all subjects by measuring the longest dimension (A), the shortest dimension (B), and using the formula $\pi \times A \times B/4$. The volume of the antropyloric region of the stomach can be cal-

Table 1. Calories and nutritional components in soup (100 g)

Fat	Calorie	Protein	Carbohydrate	Na
12 g	410 kcal	8 g	68 g	2,400 mg

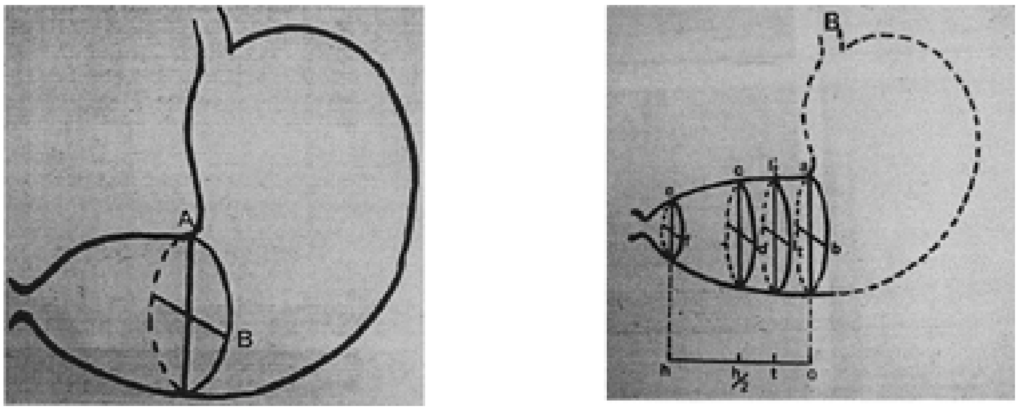

Fig. 1. Bolondi *et al.*'s method; area method (left) and volume method (right). A: the longitudinal diameter, B: the anteroposterior diameter of cross sectional area of the gastric antrum, a: the longitudinal diameter, c: longitudinal diameter angle at intermediate level, e: longitudinal diameter angle at pylorus, b: anteroposterior diameter at angle region, d: anteroposterior diameter at intermediate level, f: anteroposterior diameter at pylorus, h: antral length.

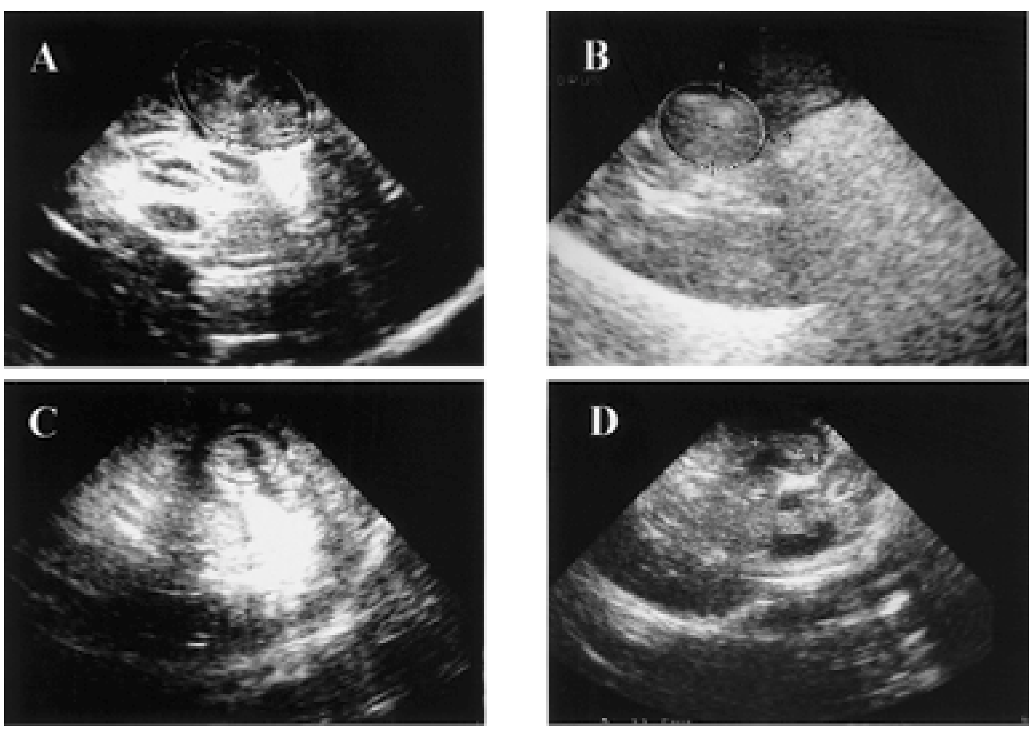

Fig. 2. Measurement of pyloric area (A) and pyloric antrum volume (A, B, C & D) by Bolondi *et al.*'s method. (A: a, b, B: c, d, C: e, f, D: h)

culated from these measuments according to the formula; $0.065 \times h \times (2ab + 2ef + 4cd + cb + ad + ed + cf)$, where h is the antral length; a, c and e are the longest dimensions; and b, d, and f are the shortest dimensions at three different levels with slight reposition of the transducer (Figs. 1 and 2). Real-time frames (images) which are necessary for measurment could be captured by replaying in image memory function built in the machine. The frequency of antral contractions was defined as the number of contractions per min after feeding saline or soup.

The GET is the time determined when the stomach returned to the basal values. The GET data obtained in area method were compared with those of volume method in both saline and soup groups using paired Student's *t*-test.

Modification of the antrum area and volume after saline and soup feeding was calculated in terms of basal values

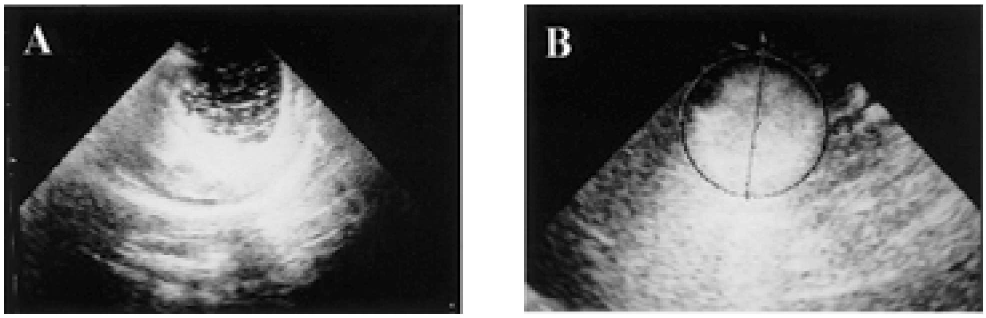

Fig. 3. Ultrasonographic images of pyloric antrum with saline (A) and soup (B).

(values prior to feeding) and then transferred to a curve in relation to times. Values of $p<0.05$ were considered significant.

RESULTS

Ultrasonographic images of pyloric antrum with saline were anechoic patterns with multiple bright dots, whereas the images with soup were found as a hyperechoic pattern with less contrast compared to that of saline solution (Fig. 3).

The mean values of contraction number of pyloric antrum in saline and soup group were 4.19 ± 1.30/min and 4.82 ± 0.65/min before feeding, and overall mean values were 4.66 ± 1.37/min and 5.13 ± 1.71/min, respectively (Table 2). The values increased after feeding the saline and soup solution and there was significant correlation between contraction frequency and area ($r=0.854$, $p<0.05$) or volume method ($r=0.911$, $p<0.05$) in soup group.

In saline group, the GET by area increased to its maximum level after feeding saline immediately, then decreased thereafter to its basal value, whereas the GET by volume increased to its maximum level at 20 min after feeding, then it decreased thereafter to its basal value (Fig. 4). In soup group, the GET by area and volume increased shortly after feeding, then decreased gradually to the basal value (Fig. 5).

Final emptying times (mean ± S.D.) calculated according to the changes in the cross-sectional area and volume of the gastric antrum were 36.73 ± 11.27 min, 40.00 ± 8.87 min in the saline-fed dogs, respectively, and were 61.35 ± 17.58 min and 59.11 ± 14.46 min in the soup-fed dogs (Table 2). All dogs were placed on the V-shape positioner for 60–80 min in saline group and for 60–100 min in soup group until the stomach was completely empty. In the GET of saline and soup groups, there was no significant difference between the area and volume method ($p>0.05$).

DISCUSSION

As ultrasonic observation of pylorus was bull's eye or target like appearance with hypoechogenecity in center and hyperechogenecity in outlayer, and the length of pyloric canal was less than 20 mm, it was somewhat consistent with that of Agut *et al.*'s report [1]. The mean pyrolic contractions of saline and soup groups before feeding were 4.19 ± 1.30, 4.82 ± 0.65 per min and overall contractions during feeding were 4.66 ± 1.37, 5.13 ± 1.71 per min which is similar to the result of 4–5 frequency per min by Penninck's report [19].

For yielding optimal images of the pyloric antrum, various positions such as dorsal recumbency, ventral recumbency and lateral oblique positions were done. Among them, dorsal recumbency was the most helpful for stable position and it was easier to use the additional V-shaped positioner.

In dorsal recumbency, if the stomach is empty, the gas in the stomach sometimes make it difficult to see the pylorus, but changing to the right lateral position make it possible to examine the pylorus because of moving the gas into the fundus. This positional shifting is similar in human examina-

Table 2. Gastric motility in saline and soup-fed dogs (mean ± SD)

Test fluids	Antral contraction (no./min)	Gastric emptying (min) Area method	Gastric emptying (min) Volume method
Saline	4.66 ± 1.37	36.73 ± 11.27	40.00 ± 8.87
Soup	5.13 ± 1.71	61.35 ± 17.58	59.11 ± 14.46

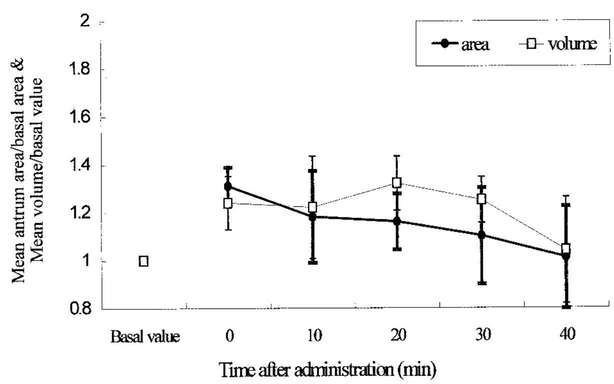

Fig. 4. Gastric emptying time (GET) in saline-fed group by ultrasonic area and volume method.

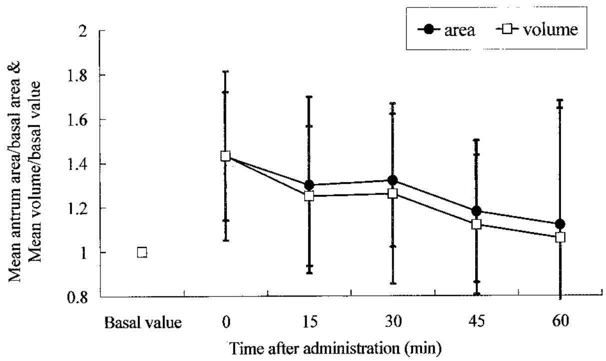

Fig. 5. Gastric emptying time (GET) in soup-fed group by ultrasonic area and volume method.

tion [4] that between in the supine and upright position the upright position is the best way to detect food contents within the antrum because contents is influenced by gravity and they tend to fall into the antrum.

In examining the pylorus filled with saline solution was shown as an anechoic pattern with multiple bright dots (small refractile dots) with high contrast, whereas the pylorus filled with soup was found as a hyperechoic pattern with less contrast compared to that of saline solution. It could be explained that these microcavitations (microbubbles) entrapped in an agitated saline liquid could make hyperechoic patterns and sometime it was also found in empty stomach, in which some debris in the stomach was mixed with saline solution, which made some hyperechoic patterns.

In gastric emptying studies with barium meal, Miyabayashi & Morgan [17] reported that complete gastric emptying time of the intact kibble and ground kibble meals of a given dose (8 g/kg of dog food plus 5–7 m*l*/kg of the contrast agent) ranged from 5–10 hr with intact kibble meal and 7.0 ± 1.86 hr with ground kibble meal. Burns & Fox [5] reported that total gastric emptying time ranged from 7.0–15.0 hr with contrast mean (7 m*l*/kg B.W., barium sulfate mixed with 8 g/kg B.W. ground kibble). In gastric emptying study with liquid test meal (11 m*l*/kg of a 3% solution of phenol red dye), Leib *et al.* [16] reported that the canine stomach started to empty as a function of the square root of the volume of meal in the stomach at 1.9 min, emptied one-half of the test meal by 20.9 min and was empty by 52.4 min.

In comparison of these data with our data, it is difficult to compare because of different test meals. But our data is very similar to that of Leib *et al.* [16] with liquid meals.

Among those techniques, Hveem *et al.* [12] reported that ultrasound measurement was of comparable sensitivity to scintigraphy in quantifying emptying of both low and high nutrient liquids, and Bateman & Whittingham [2] reported that real time ultrasound can be used for gastric emptying time, but it may be difficult to perform in many cases due to the inability to take measurements at the level of the body and fundus of the stomach. Bolondi *et al.* [4] also reported that ultrasonography was a good method to measure the GET by measuring the gastric antrum. In this study with Bolondi *et al.*'s [4] method, area and volume method can be performed in all subjects, and the area method is much simpler than volume method. Though the latter is more accurate, the measurement is quite cumbersome and time consuming in our experiment, which is same with Bolondi *et al.*'s experience. In accordance with the result of Bolondi *et al.*'s method, we found that there were no differences between area and volume methods with paired *t*-test. Therefore, both methods were applicable to assess the GET in dogs. After publishing of Bolondi's method, the reproducibility and other availabilty of this method were confirmed [6, 7, 13, 22] in human medicine.

Since there was no report on the GET with ultrasound in veterinary medicine, it is concluded that simplified and accurate measuring method such as Bolondi *et al.*'s [4] method would be needed in veterinary field.

In measuring the GET by area and volume method, it is found that the image memory function built in the machine is useful for capturing the real-time images of pyloric region of stomach. With this, past images for 2–3 sec could be obtained by replaying with the knob. And this also could be possible by recording the real-time images using the video-recroding system.

Considering of other methods for the GET, X-ray evaluation would be necessary to take a large number of radiographs with increased radiation, and the scintigraphic method is also rather time consuming and much more expensive than ultrasound technique. To evaluate the gastric emptying time (GET), radiographic contrast studies [5, 17], scintigraphy with radioisotopes [11, 12], ultrasonography [2, 4, 14, 22], radiopaque markers, such as barium-impregnated polyspheres, CT and MRI scan, dye dilution method, measurement of blood concentration of interstinal absorbed drugs such as paraacetamol are some methods and others [9, 10, 12, 16] have been used clinically in human beings and dogs. Each of these techniques has advantages and disadvantages compared each other, and there are few data which deal comparison of the ultrasound measurements with other methods for gastric emptying. Among the GET methods, paraacetamol absorption kinetics after the oral ingestion of the drug has been used as an index of gastric and not requiring special equipment [10, 18, 23]. So it is considered that it would be more useful and objective to evaluate this ultrasonographic measurements with the help of paraacetamol absorption method for gastric emptying.

In conclusion, Bolondi *et al.*'s [4] method using ultrasound is simple and repeatable, and accurate method for the functional analysis of stomach and it could be further applied to many other diseases related to gastric motility.

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