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Influence of simethicone and fasting on the quality of abdominal ultrasonography in dogs

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Abstract: The presence of a significant quantity of gas in the gastrointestinal tract may hinder a proper ultrasonographic examination of the abdominal organs. The objective of this study was to investigate the influence of simethicone and fasting on the quality of ultrasonographic examinations of the gastrointestinal tract and the small organs in the abdominal cavity. Fourteen clinically healthy dogs were examined repeatedly after four different preparation protocols. The visualisation of the organs was assessed subjectively with a 3-point scoring system. The administration of simethicone is superior in the visualisation of the ileum, the ileocolic junction, the pancreas (body and right lobe), the jejunal lymph nodes, and both adrenal glands when compared to no preparation. The combination of the oral administration of simethicone and fasting is superior in the visualisation of the pylorus, the duodenum, the jejunum, the ileum, the ileocolic junction, the pancreas (body, right and left lobe), the jejunal lymph nodes, and both adrenal glands when compared to no preparation. The conclusion and clinical relevance from this exploratory study suggest that the oral administration of simethicone and fasting before an ultrasonographic examination significantly improve the visualisation of some abdominal organs.

Keywords: gas; gastrointestinal tract; image quality; ultrasound

An ultrasonographic (USG) examination of the abdominal cavity has become a routine procedure and an irreplaceable step in the diagnostics of many diseases in veterinary medicine. The diagnostic quality of a USG examination depends on many factors, including the equipment's resolution, the experience of the operator, the body habitus, the animal's compliance, and artefacts produced by intestinal gas (Barberet et al. 2008; Pinto et al. 2011). Several authors recommend fasting, if possible, as an important preparation method for the patient before a USG examination (Ohlerth 2011; Nyland et al. 2015; Penninck 2015). A study performed in a cohort of dogs showed that the presence of intraluminal gas, which can influence the visibility of the organs, was not affected by whether the patient was fasted (Garcia and Froes 2014). The visibility of abdominal organs did not differ between fasted

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and non-fasted patients in one study from human medicine (Sinan et al. 2003). Articles that evaluate the effect of preparation protocols (PLs) before a USG examination are available. The combination of fasting with a laxative, anti-foaming agents, and deaerated water was used to reduce the presence of gas and to increase the quality of the USG images (Heldwein et al. 1987; Pinto et al. 2011).

Simethicone, an anti-foaming agent, is comprised of a chemical mixture of polydimethylsiloxane and hydrated silica gel. It reduces the surface tension, allowing bubbles to coalesce so that they can be passed more easily. Simethicone is not absorbed from the gastrointestinal (GI) tract and can be used safely in dosages at or near that of human beings (Matz 2005; Gaschen 2010).

A study about the combination of simethicone and fasting was published in a group of New Zealand white rabbits and it revealed a positive influence on the quality of the abdominal USG (da Silva et al. 2017).

To the best of our knowledge, no study about the use of simethicone and its impact on the quality of an abdominal ultrasound has been published about dogs.

The authors hypothesised that the use of fasting, simethicone, and the combination of both will increase the visualisation of the organs during abdominal ultrasonography in dogs.

MATERIAL AND METHODS

The institution gave ethical approval for this study. All of the owners of the examined dogs gave their written informed consent to the participation of their animals in the study.

Animals

This crossover study was conducted prospectively from July 2018 to November 2018. It included clinically healthy dogs owned by employees of the institution. Each dog enrolled in the study was examined four times, each time with a different PL before the USG examination. All the animals were clinically evaluated for the estimation of the body condition score and weighed before each examination. A total of fourteen clinically healthy dogs were involved in the study.

Method

Fifty-six abdominal USG examinations were executed. Four groups with the same number of examinations (14) were created based on the preparation PL. Four different preparation PLs were used in the study (Table 1).

The sonographer was not blinded to the preparation PL used before each examination, but the dogs were examined in random order because the PL was chosen for each dog by its owner.

All the USG examinations of the abdominal cavity were executed on a Vivid 7 ultrasound machine (General Electric Vingmed Ultrasound, Horten, Norway). A micro-convex probe with frequency ranges from 4 MHz to 8 MHz was used in all of the dogs. All of the examinations were performed by the same operator. The intervals between the examinations of the same dog were at least 24 hours. The examination was focused on the ability to visualise parts of the GI tract – the pylorus, duodenum, jejunum, ileum, ileocolic junction and the small organs of the abdominal cavity in the proximity of the GI tract – the pancreas, adrenal glands, jejunal lymph nodes (LN). All the examinations were performed in the same manner, starting with the patient in right lateral recumbency and followed by left lateral recumbency.

Table 1. Methods of preparation before the USG examination for each PL

PL	Methods of preparation before the USG examination
PL 1	Dogs without fasting and without the administration of any medication affecting presence of gas in the GI tract
PL 2	Dogs with at least 12 h of fasting and without the administration of any medication affecting presence of gas in the GI tract
PL 3	Dogs without fasting and with the oral administration of simethicone (Espumisan drops 100 mg/ml; Berlin-Chemie, Menarini, Berlin, Germany) in dosage 1 ml t.i.d.† day before the examination and one dosage 30 min before the examination
PL 4	Dogs with at least 12 h of fasting and with the oral administration of simethicone (Espumisan drops 100 mg/ml; Berlin-Chemie, Menarini, Berlin, Germany) in dosage 1 ml t.i.d.† day before the examination and one dosage 30 min before the examination

GI = gastrointestinal; PL = protocol; USG = ultrasonographic

†Three times a day

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Ultrasonography interpretation

The image quality was defined by a scoring system adapted from two previously published articles about the quality assessment of abdominal USGs in veterinary and human medicine (Sinan et al. 2003; Garcia and Froes 2014). The visualisation of the organs was assessed subjectively with a 3-point scoring system – excellent (1), acceptable (2), and unacceptable (3). "Excellent" meant that the image quality allowed the clear definition of the anatomy of the organs that would be of suitable clarity for publication. "Acceptable" meant that the visualisation of the organs was adequate for the clinical purpose, and there was no need to repeat the examination. "Unacceptable" did not allow an adequate organ evaluation due to a technical failure, and a re-evaluation was recommended. All of the data were recorded in a scoring table, which was available for analysis after the termination of all of the examinations.

Table 2. Scoring of the visualisation of each organ due to the preparation protocol

Abdominal organs		Protocol 1	Protocol 2	Protocol 3	Protocol 4
	excellent	2	5	4	7
Pylorus	acceptable	9	9	10	7
	unacceptable	3	0	0	0
	excellent	1	5	4	7
Duodenum	acceptable	12	6	9	7
	unacceptable	1	3	1	0
	excellent	1	4	5	9
Jejunum	acceptable	10	8	8	5
	unacceptable	3	2	1	0
	excellent	0	1	1	7
Ileum	acceptable	8	9	11	3
	unacceptable	6	4	2	4
	excellent	0	2	4	7
Ileocolic junction	acceptable	8	8	10	5
	unacceptable	6	4	0	2
	excellent	1	1	6	10
Body of pancreas	acceptable	5	9	7	4
	unacceptable	8	4	1	0
	excellent	4	7	6	11
Left pancreatic lobe	acceptable	6	7	7	3
	unacceptable	4	0	1	0
	excellent	0	4	10	10
Right pancreatic lobe	acceptable	11	9	4	4
	unacceptable	3	1	0	0
	excellent	1	3	8	11
Left adrenal gland	acceptable	8	8	5	2
	unacceptable	5	3	1	1
	excellent	3	3	9	9
Right adrenal gland	acceptable	9	8	4	5
	unacceptable	2	3	1	0
	excellent	1	2	7	8
Jejunal LN	acceptable	1	5	4	2
	unacceptable	12	7	3	4

LN = lymph nodes

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Data and statistical analysis

Commercial statistical software was used to perform the analysis (Minitab 16; Minitab Inc., Coventry, UK). Ordinal logistic regression was used to determine the differences in the scoring between protocols. The decision as to which preparation PL was superior to another PL was made based on the scoring table (Table 2). All the preparation PLs were compared separately for each evaluated organ. All the analyses were performed at a 5% significance level.

RESULTS

The mean age of the dogs was 5.95 ± 2.91 years, represented by eight intact females, three spayed females, one intact male, and two castrated males. The mean weight of the dogs was 18.89 ± 13.15 kg. Nine different breeds were represented – Dachshund (3), Rhodesian Ridgeback (3), Parson Russell Terrier (2), Small Munsterlander (1), Basenji (1), Staffordshire Bull Terrier (1), German Shorthaired Pointer (1), Fox Terrier (1), and Doberman (1).

Table 2 shows the descriptive analysis of the scoring for each organ separately. The *P*-values of the ordinary logistic regression test comparing the scoring system of the preparation PL for the parts of the GI tract (pylorus, duodenum, jejunum, ileum, ileocolic junction) are shown in Table 3. The *P*-values of the ordinary logistic regression test comparing the scoring system of the preparation PL for the small organs of the abdominal cavity in the proximity of the GI tract (pancreas, adrenal glands, jejunal LN) are shown in Table 4.

Fasting (PL 2) is superior in the visualisation of the pylorus ($P = 0.034$), ileocolic junction ($P = 0.028$), right pancreatic lobe ($P = 0.041$) and left pancreatic lobe ($P = 0.027$) in comparison with no preparation (PL 1).

The oral administration of simethicone (PL 3) is superior in the visualisation of the ileum ($P = 0.01$), ileocolic junction ($P = 0.022$), body of pancreas ($P = 0.001$), right pancreatic lobe ($P < 0.001$), left adrenal gland ($P = 0.003$), right adrenal gland ($P = 0.023$) and jejunal lymph nodes ($P = 0.001$) in comparison with no preparation (PL 1). The oral administration of simethicone (PL 3) is supe-

Table 3. *P*-values of the ordinary logistic regression test comparing the scoring system of the preparation PL on the visualisation of the GI parts

Protocols comparison	Pylorus	Duodenum	Jejunum	Ileum	Ileocolic junction
PL 1 vs PL 2	0.034*	0.439	0.686	0.256	0.028*
PL 1 vs PL 3	0.067	0.151	0.683	0.010*	0.022*
PL 1 vs PL 4	0.007*	0.023*	0.001*	0.012*	0.003*
PL 2 vs PL 3	0.686	0.561	0.445	0.071	0.855
PL 2 vs PL 4	0.447	0.140	0.001*	0.129	0.379
PL 3 vs PL 4	0.250	0.352	0.005*	0.958	0.451

GI = gastrointestinal; PL = protocol

*Significant difference

Table 4. *P*-values of the ordinary logistic regression test comparing the scoring system of the preparation PL on the visualisation of the small abdominal organs

Protocols comparison	Body of pancreas	Right pancreatic lobe	Left pancreatic lobe	Jejunal LN	Left adrenal gland	Right adrenal gland
PL 1 vs PL 2	0.172	0.041*	0.027*	0.074	0.272	0.765
PL 1 vs PL 3	0.001*	< 0.001*	0.056	0.001*	0.003*	0.023*
PL 1 vs PL 4	< 0.001*	< 0.001*	0.001*	0.001*	< 0.001*	0.018*
PL 2 vs PL 3	0.027*	0.024*	0.577	0.042*	0.053	0.028*
PL 2 vs PL 4	0.001*	0.022*	0.135	0.047*	0.006*	0.015*
PL 3 vs PL 4	0.112	1.000	0.053	0.918	0.270	0.889

PL = protocol

*Significant difference

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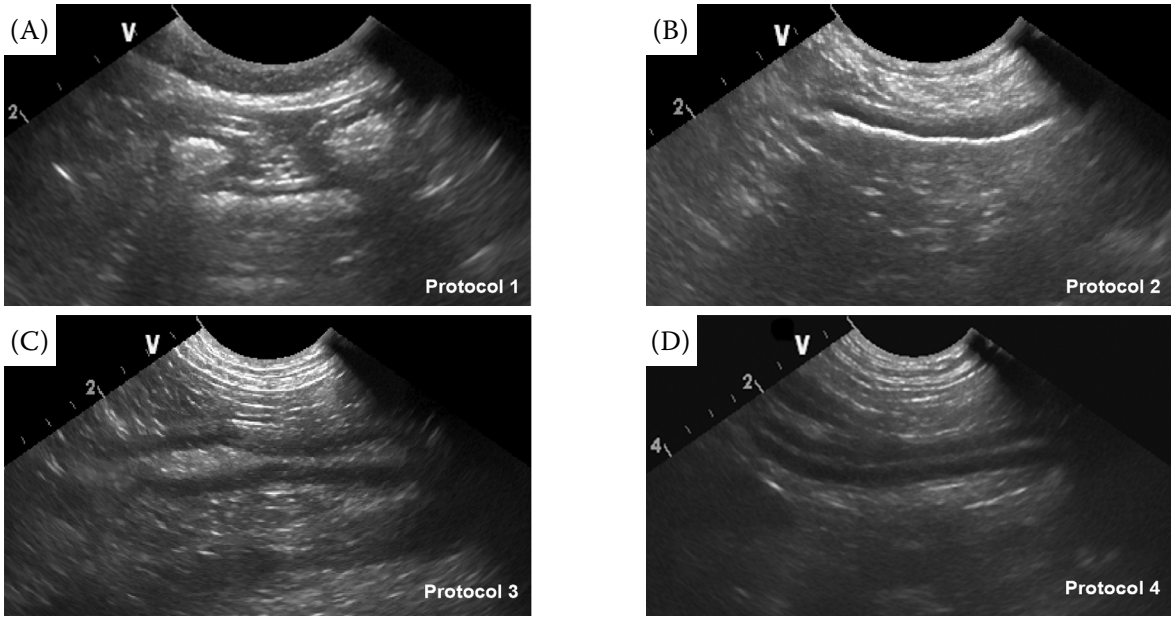

Figure 1. Ultrasonographic (USG) images of the jejunum

(A, PL 1) Jejunal intestinal loops with an alimentary and a gas pattern. Only the wall layers of the intestinal loop close to the probe are visible, but the presence of food interferes with the complete evaluation of this wall. (B, PL 2) Presence of a gas pattern as a hyperechoic reflective surface with a reverberation artefact. Only the wall layers of the intestinal loop close to the probe are visible. (C, PL 3) Jejunal intestinal loop with an alimentary pattern. The wall layers of intestinal loops are visible, but the presence of food interferes with the complete evaluation. (D, PL 4) Jejunal intestinal loops with a mucous pattern. No artefacts are present. The intestinal wall layers of the jejunum are clearly visible for the complete evaluation

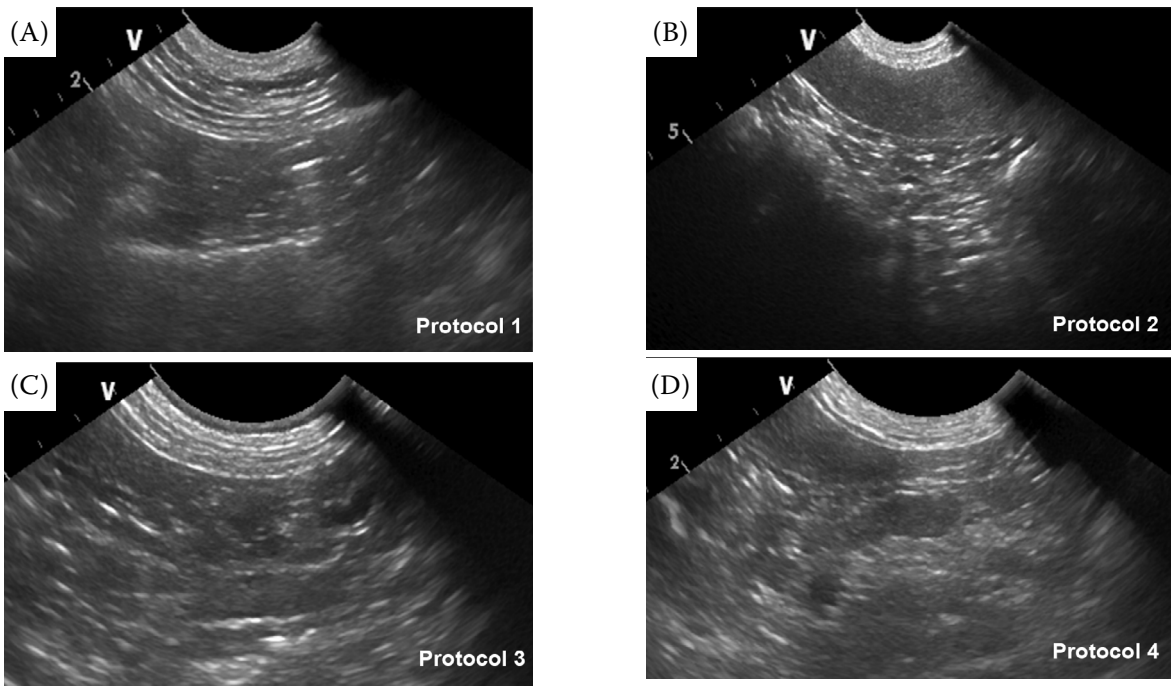

Figure 2. Ultrasonographic (USG) images of the jejunal LN

(A, PL 1) (B, PL 2) The region of the jejunal LN along the cranial mesenteric vascular tree is visualised. The LN are not visible due to verberation artefact from gas in the GI tract. (C, PL 3) (D, PL 4) Jejunal LN are visible along the mesenteric vascular tree. No artefacts are present. Jejunal LN are clearly visible for the complete evaluation

GI = gastrointestinal; LN = lymph nodes

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rior in the visualisation of the body of the pancreas (P = 0.027), right pancreatic lobe (P = 0.024), right adrenal gland (P = 0.028) and jejunal lymph nodes (P = 0.042) in comparison with fasting (PL 2).

The combination of fasting and the oral administration of simethicone (PL 4) is superior in the visualisation of the pylorus (P = 0.007), duodenum (P = 0.023), jejunum (P = 0.001), ileum (P = 0.012), ileocolic junction (P = 0.003), body of the pancreas (P < 0.001), right pancreatic lobe (P < 0.001), left pancreatic lobe (P = 0.001), right adrenal gland (P = 0.018), left adrenal gland (P < 0.001) and jejunal lymph nodes (P = 0.001) in comparison with no preparation (PL 1).

The combination of fasting and the oral administration of simethicone (PL 4) is superior in the visualisation of the jejunum (P = 0.001), body of the pancreas (P = 0.001), right pancreatic lobe (P = 0.022), right adrenal gland (P = 0.015), left adrenal gland (P = 0.006) and jejunal lymph nodes (P = 0.047) in comparison with fasting (PL 2). The combination of fasting and the oral administration of simethicone (PL 4) is superior in the visualisation of the jejunum (P = 0.005) in comparison with the oral administration of simethicone solely (PL 3).

The USG images of the jejunum and the jejunal LN from each preparation PL are attached (Figure 1, Figure 2, respectively).

DISCUSSION

The quality of a USG examination depends on many factors. The authors of the present study focused on the effect of the contents of the GI tract, represented by food and gas. In the present study, the authors aimed to reduce other variabilities by using the same technical equipment and operator for all of the USG examinations. The micro-convex probe with a frequency range from 4 MHz to 8 MHz was used in all of the dogs, the frequency was chosen according to the size of the animal. To reduce the variability of the body habitus and compliance, the same fourteen animals underwent the examination repeatedly over a period of 5 months. No significant changes in the body habitus of these animals occurred during the study period.

The visualisation of the pylorus was significantly superior after fasting (PL 2) and after a combination of simethicone and fasting (PL 4) when compared to no preparation (PL 1). This improvement could be explained by the absence of food in the stomach, which prevented the complete examination. Fasting for 6 h to 12 h before the USG examination of the GI tract is recommended, if possible (Ohlerth 2011; Nyland et al. 2015; Penninck 2015).

The duodenum was examined in left lateral recumbency. In the present study, the visualisation of the duodenum was significantly superior after a combination of simethicone and fasting (PL 4) when compared to no preparation (PL 1). This finding has not been reported previously. There was no positive effect on the visualisation of the duodenum for fasting alone (PL 2) when compared to no preparation (PL 1). This is in agreement with a previous study, where fasting provided no positive effect on the quality of the visualisation of the duodenum (Garcia and Froes 2014).

In this study, the visualisation of the jejunum was significantly superior after the combination of simethicone and fasting (PL 4). This significant improvement was detected when compared to all of the other preparation groups – no preparation (PL 1), fasting (PL 2), and simethicone (PL 3). The same significant image-quality improvement for the jejunum was documented in New Zealand white rabbits after the combination of the oral administration of simethicone and fasting (da Silva et al. 2017).

The visualisation of the ileum was significantly superior after the administration of simethicone (PL 3) and the combination of simethicone and fasting (PL 4) when compared to no preparation (PL 1). No information in the literature is available about the visibility improvement in this part of the GI tract.

The visualisation of the ileocolic junction was significantly superior after fasting (PL 2), simethicone (PL 3), and a combination of simethicone and fasting (PL 4) when compared to no preparation (PL 1). The interference of a gas-filled caecum on the visualisation of the ileocolic junction was described in the literature (Penninck 2015). No information is available in the literature about the visibility improvement in this part of the GI tract.

A USG can be used to evaluate the LN characteristics only if a suitable acoustic window is attained. In a previous study, the positive correlation between the body weight and the visibility of the LN was recorded (Barberet et al. 2008). We chose the jejunal LN because of their localisation near the root of the mesentery and along the cranial mes-

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enteric vascular tree. Due to their deep-seated localisation, a micro-convex probe with a frequency range of 4 MHz to 8 MHz was the best option for the visualisation of the jejunal LN in all of the dog sizes in the study. The visualisation of the jejunal LN was significantly superior after the administration of simethicone (PL 3) and the combination of simethicone and fasting (PL 4) when compared to the dogs without a preparation (PL 1). Moreover, both groups were (PL 3 and PL 4) significantly superior in the visualisation of the jejunal LN when compared to fasting (PL 2).

The type of patient preparation significantly improved the visualisation of all of the pancreatic parts. The negative influence of GI gas on the visualisation of the pancreas was confirmed in a previous study (Barberet et al. 2008). The visualisation of the left pancreatic lobe was significantly superior after fasting (PL 2) and the combination of simethicone and fasting (PL 4) when compared to no preparation (PL 1). The visualisation of the right pancreatic lobe was significantly superior after fasting (PL 2), simethicone (PL 3), and the combination of simethicone and fasting (PL 4) when compared to no preparation (PL 1). A significantly superior visualisation of the right pancreatic lobe was detected after the administration of simethicone (PL 3) and the combination of simethicone and fasting (PL 4) when compared to fasting (PL 2). The visualisation of the body of the pancreas was significantly superior after the administration of simethicone (PL 3) and the combination of simethicone and fasting (PL 4) when compared to no preparation (PL 1) and when compared to fasting (PL 2).

The visualisation of the left and the right adrenal gland was significantly superior after the administration of simethicone (PL 3) and the combination of simethicone and fasting (PL 4) when compared to no preparation (PL 1). The visualisation of the right adrenal gland was significantly superior after the administration of simethicone (PL 3) when compared to fasting (PL 2). The visualisation of both adrenal glands was significantly superior after the combination of simethicone and fasting (PL 4) when compared to fasting (PL 2). The adrenal glands can be evaluated completely in most dogs during a routine abdominal USG. This is especially true in small-breed dogs (Grooters et al. 1994). The examination of the adrenal glands is difficult due to the presence of gas in the pylorus and duodenum, which tends to be more of a problem on the right side than on the left (Grooters et al. 1994). A faeces-filled colon could interfere with the visualisation of the left adrenal gland (Garcia and Froes 2014). A previous report stated that the body condition score has a positive influence on the visibility of the right adrenal gland (Barberet et al. 2008).

A limitation of the current study is that the sonographer was not blinded to the preparation PL during the examination. On the other hand, the dogs were examined in a random order regardless of the preparation PL. The preparation PL applied to each dog was chosen by the owner and it was not influenced by the sonographer. The sonographer examined several dogs with different preparation PLs in one day. Moreover, all the data were recorded in a scoring table, which was available for analysis only after the termination of all of the examinations. Another limitation of the study was observed during the USG examination. There was a variance in the food type among the dogs enrolled in the study. The dogs were fed with commercially prepared dry food, cooked meals, and biologically appropriate raw food (BARF). This diversity could lead to different amounts of gas produced in the GI tract. On the other hand, no changes in the diet of each dog were made during the trial period; therefore, the representation of the different types of food was consistent among the four groups.

In conclusion, the fasting and especially its combination with the oral administration of simethicone significantly improved the visualisation of some abdominal organs. The authors of the present study suggest the usage of simethicone and its combination with fasting before a USG examination, especially in patients that should be examined repeatedly due to difficulties with the visualisation of the abdominal organs caused by the presence of gas in the GI tract.

Future research with more animals, including animals with GI tract pathologies, and a blinded study design is needed to prove the potential usage of simethicone and evaluate its real impact on the quality of the USG examination. More studies focused on the timing of the administration of simethicone before the examination are needed to prove its usefulness in daily practice.

Conflict of interest

The authors declare no conflict of interest.

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