Brief Communication
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Stomach Gas Analyses in Canine Acute Gastric Dilatation with Volvulus

H.J. Van Kruiningen, C. Gargamelli, J. Havier, S. Frueh, L. Jin, and S. Suib

Background: The origin of the gas in the stomachs of dogs with acute gastric dilatation or gastric dilatation with volvulus (GDV) often is disputed.

Hypothesis: We tested the hypothesis that gaseous distention resulted from aerophagia.

Animals: Ten cases of GDV that were submitted to an emergency clinic were sampled intraoperatively.

Methods: With the abdomen open, the needle of a vacutainer blood collection set was inserted into the distended stomach, and gas was collected into 10 mL glass vacutainer vials with rubber stoppers. These were stored at room temperature for 1–7 days and then analyzed by gas chromatography and mass spectroscopy.

Results: CO_2 composition ranged from 13 to 20%. One dog had an H_2 concentration of 29%.

Conclusions: Because the CO_2 content of atmospheric air is less than 1%, these findings suggest that the gaseous gastric distention in GDV is not the result of aerophagia.

Key words: Aerophagia; AGD/GDV; Gastric dilatation; Gastric gas; Gastric volvulus; Gastroenterology; Stomach.

In 2006, a breeder of several purebred breeds of dogs (Great Danes, Mastiffs, and Neapolitan Mastiffs) in Japan experienced 30 instances of acute gastric dilatation (AGD) or gastric dilatation with volvulus (GDV) in 17 dogs. Eleven of 17 died. Each of these cases occurred within several hours after consuming a commercial cereal-based diet. Investigation of these cases, all associated with consumption of a single brand-named kibble, led to consideration of the role of diet versus aerophagia in the pathogenesis of AGD/GDV.

At a later time, we established a collaboration to sample and analyze the stomach gas of dogs submitted to an emergency clinic for GDV surgery. During the present study, it was not feasible to sample normal animals or other patients as controls. This study was not designed to test normal gastric gas concentrations, because reference values previously have been established.[1,2] We initiated this study to test the hypothesis that the gastric gas in dogs with GDV is not atmospheric air.

Materials and Methods

At the emergency clinic, the diagnosis was established and the dog was prepared for surgery. Once the abdomen was incised, a 23-gauge needle on a vacutainer blood collection set[a] was inserted into the distended body of the stomach. After 1–2 seconds (allowing gastric gas to clear the tubing), the needle on the distal end of the collection tubing was inserted into a glass 10 mL BD[a] vacutainer vile without additives. After 1 minute, the needle was removed from the rubber vial stopper and the proximal needle was removed from the stomach of the dog. Gas-filled vials were labeled and stored at room temperature. They were picked up after 1 to several days and delivered to the Department of Chemistry at the University of Connecticut.

Gas composition was measured using an SRI 8610C gas chromatograph (GC) equipped with a thermal conductivity detector (TCD).[b] A sample loop was used to provide precise injection volumes. Gases were withdrawn through the rubber stopper of the vacutainer sample vials using 1 mL gas-tight syringes. Syringe contents then were immediately delivered through the GC injection port. Identity of molecular analytes was determined by retention time. Composition was calculated from peak area. A HAYE-SEP D silica gel column[c] was used to separate H_2, CO_2, CO, and H_2S. A molecular sieve column was used to separate H_2, O_2, N_2, and methane. H_2O was excluded from composition calculations.

Additional confirmation of identity was provided by mass spectroscopy using an MKS Cirrus residual gas analyzer.[d] Contents of the gas tight syringe were injected into a custom-built, stainless steel, argon-purged sampling manifold. The manifold was maintained at room temperature.

Abbreviations:

AGD	acute gastric dilatation
GDV	gastric dilatation with volvulus

Results

Ten cases of GDV were studied. No cases of simple AGD occurred in this series. Breeds affected were Mastiff, Doberman Pinscher, Akita, Great Dane (2), Labrador Retriever (3) and German Shepard Dog (2). Three were spayed females; 7 were castrated males. Ages ranged from 2.5 to 11 yrs. Dog foods associated with the GDV were Nutro Venison and Rice,[e] Chicken Soup for Dog Lovers-canned and dry,[f] Iams Lamb & Rice[g] small bite, Pedigree Senior,[h] Bil-Jack,[i] and Evolution.[j] The gastric CO_2 concentrations ranged from 13 to 20% (composition of air 0.03%).[3] One dog had an H_2 concentration of 1% and another, 29% (composition of air 5×10^{-5}%).[3] Relative concentrations of O_2 and N_2 were reduced; O_2 12–19% (composition of air 20.9%)[3]; N_2 41–68% (composition of air 78.1%).[3]

From the Department of Pathobiology and Veterinary Science, University of Connecticut, Storrs (Van Kruiningen); the Animal Emergency Hospital of Central Connecticut, Rocky Hill (Gargamelli, Havier); and the Department of Chemistry, University of Connecticut, Storrs, CT (Frueh, Jin, Suib).

Corresponding author: H.J. Van Kruiningen, Department of Pathobiology and Veterinary Science, University of Connecticut, Storrs, CT 06269; e-mail: herbert.vankruiningen@uconn.edu

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Discussion

Previously, it has been shown that the gas in AGD and GDV cases was not atmospheric air, but rich in CO_2, and contained some H_2.[1,2] In addition, we documented that stomach contents obtained at necropsy continued to bubble and expand plastic containers until the tops popped off, reminiscent of fermentative bloat in cattle.[1] In the past, gas analysis data were criticized because there had been variable delays between the time of death and the time of gas collection at necropsy. A later study by Rogolsky et al showed that 1 dog, which was sampled immediately before euthanasia, had 60.2% CO_2 and 1.8% H_2.[2] Dogs that had died of AGD had gastric lactic acid concentrations 9 times higher than controls.[2]

In 1977, Caywood et al. reported gastric gas analyses in 7 cases of GDV, each sampled before surgery. Relative CO_2 concentrations ranged from 1.0 to 24%.[4] The CO_2 concentration of atmospheric air is less than 1%.[3] These investigators collected their gas specimens in plastic syringes, and these were held refrigerated for up to 8 hours before analysis. Plastics, however, are permeable and allow gas diffusion.[5] Thus, some equilibrium with atmospheric air may have occurred in the Caywood et al study[4]; the values for CO_2 and H_2 may have been higher than those reported.

We used glass containers with stopcocks in our earlier studies, and in the present study, glass vacutainers with rubber stoppers were used. The latter have been reported to be ideal.[5] Our data indicated 13–20% CO_2, and in 1 dog 29% H_2. These data suggest, at least in the cases we studied, that aerophagia was not the cause of GDV.

Both aerobes and anaerobes produce H_2 from various substrates,[6] clostridia being most notorious.[7] Previously, we reported gastric H_2 concentrations of 0–0.2% in control dogs and concentrations up to 5% in dogs with AGD (sampled 0–120 minutes after death).[1] In the instance of 29% reported here, we suggest the bacterial flora of the stomach was different from that of the other 9 cases.

Although it is sometimes suggested that diffusion of CO_2 from the vasculature to the gastric lumen might explain the CO_2 in GDV, there is no evidence to support this contention. Although CO_2 can diffuse against a pressure gradient, the very high concentrations of blood CO_2 that would be required for this to occur are not compatible with life. The idea that gastric gas in GDV is the product of salivary bicarbonate reacting with gastric acid has never been tested. The distal esophagus is closed by the distention or the volvulus or both. Gases generated cannot escape by eructation, and swallowed saliva cannot enter the stomach. The latter hypothesis would not explain the H_2 production reported here and in the literature[2,4] nor the continuing distention even after death, which was documented in the dogs from Japan.

We conclude that the gases produced in GDV are the product of bacterial fermentation, either from bacteria acquired with the feed, as was suggested in cases of AGD in monkeys,[8] or from gut flora introduced by reflux from the duodenum into the gastric lumen, an event that occurs frequently.[9] Bacterial fermentation can occur quickly[7] and would explain the CO_2, H_2, and lactic acid production seen in AGD/GDV.[10] Depending on the ingredients, various fibrous substrates reacting with gut bacteria could produce between 675 mL and 18,000 mL of gas per 450 g of substrate within 4 hours.[10]

Footnotes

[a] Becton Dickinson, Franklin Lakes, NJ
[b] SRI Instruments, Torrance, CA
[c] HayeSeparations, Bandera, TX
[d] MKS Instruments, Andover, MA
[e] Nutro Natural Choice, Franklin, TN
[f] Diamond Pet Foods, Meta, MO
[g] Iams, Mason, OH
[h] Pedigree, Franklin, TN
[i] Bil-Jac, Medina, OH
[j] Evolution, St. Paul, MN

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Conflict of Interest Declaration: The authors disclose no conflict of interest.

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