Gastrointestinal (GI) tract abnormalities are a frequent reason for owners presenting small animals to their veterinarian, and foreign body (FB) dietary indiscretion, whether causing mechanical obstruction or not, is a common concern recorded as part of client communication by the attending Doctor of Veterinary Medicine (DVM). Patients may also present due to owner concern for ingestion of a FB (seen or suspected) with or without abnormal GI signs.

In classic peer-reviewed published literature, the guideline for pathological small intestinal (SI) dilation in the dog is the segmental enlargement of the SI and comparison of the maximum diameter of a SI segment to a vertebral body height (SI_{max}-to-L5 ratio < 1.6). Recent literature has supported that this characteristic is not always seen (only in approx 50% of sample size) and the ones that have increased the SI_{max}-to-L5 ratio can range from 1.8 to 2.4. As the value of the ratio increases, the higher the likelihood of an obstruction. In cats, tending to be more uniform in body size, a combination of 2 populations of SI tract and a serosa-to-serosa diameter in excess of...
12 mm have been suggestive of mechanical obstruction. Mechanical obstruction may occur due to FB ingestion, mural pathology, torsion, stricture formation, or intussusception.

In cases presenting for suspected or known FB ingestion, or with abnormal GI signs, a veterinarian’s main concern is the presence or absence of mechanical obstruction that may require endoscopic or surgical intervention. However, pet owners may also ask the veterinarian (1) if a patient has ingested any foreign material, and (2) the clinical importance of that ingestion. In cases where metal or mineral opacity objects are ingested, or where obstruction is evident per the peer-reviewed literature references, options and advice offered to clients are often straightforward. However, in the absence of evidence of metal or mineral opaque FBs or radiographic evidence of mechanical obstruction, communication with the client; however carefully or well worded, may be perceived by the client as definitively no FB being present. In cases where either mechanical obstruction later develops or foreign material is defecated, this can lead to client challenges with claims of incompetence, requests for refunds (particularly if a second opinion was sought and surgical intervention was ultimately needed), cyberbullying, or board complaints. As such, radiographs are often submitted for a second opinion to board-certified teleradiologists, to forums and message boards via social media, or to other veterinarian-accessible sources such as the Veterinary Information Network after in-house assessment. When submitted for additional opinions, radiolucent foreign bodies are frequently observed indicating that general practitioners may not be fully aware of what they are looking for during initial review. Such second opinion submissions and professional social media group postings specifically regarding concerns for missed FBs have, subjectively, been noted to be increasing over the last couple of years by one of the authors (SD) and provided the motivation for the development of this study.

Methods

Part 1

An online survey was administered between June 18, 2023, and July 2, 2023. Veterinarians were solicited through a post on a single private veterinarian-based social media group hosted on Facebook. A question was posted asking veterinarians to comment listing of confirmed FBs in companion animals pets that presented with or without GI signs and without evidence of mechanical obstruction on initial presentation. Foreign bodies needed to be confirmed either via surgery if mechanical obstruction developed or via defecation of the offending item. Items offered were tallied on a shared Google Drive Excel sheet and any objects mentioned 5 or more times were deemed “common” and included in the study. Some FBs that were named but known to primarily contain metal or mineral components were excluded; the only exception made was for “earbuds,” as noted by one of the authors (SD) that many attending DVM do not realize the electronic component within and instead focus on the outer plastic casing.

Part 2

Representative objects deemed as common causes of GI tract mechanical obstruction were acquired and radiographed applying the principles of “as low as reasonably achievable” (ALARA) as would be applied to clinical cases using a SmartDR Precision system (Sound Technologies) with a Varex 17-inch X 17-inch Gadox DR panel and MusicaVet (Sound Technologies) smart imaging processing software. Exposures were automatically selected by the system after entering a patient thickness of 5 cm, and a standard 40-inch/100-cm tube to imaging detector distance was used using a tabletop technique. Radiographic images were saved as DICOM images locally and on a remote cloud “picture archiving and communication system” (PACS) system hosted by Antech Imaging Services. A 2.5-gallon Ziplock bag with objects was radiographed to ensure it would not adversely affect the image quality of the objects selected. Objects were radiographed in groups to limit the number of exposures with the objects positioned within a 2.5-gallon Ziplock bag first containing air and then filled with water eliminating as much air as possible to mimic chyme present within the GI tract lumen. After each setup and before each exposure, a photograph of the objects was taken using an iPhone 14 Plus (Apple Incorporated) so that the location of each object on the image detector was recorded for comparison to the radiographic image at a later date. DICOM and photographic images were assessed by an American College of Veterinary Radiology board-certified veterinary radiologist (SD) and a DVM with postgraduate internship training in radiology (FY). Each reviewer independently evaluated the DICOM images using Horos version 3.3.6 (open-source DICOM software under the Lesser General Public License license at www.horosproject.com, sponsored by Nimble Co LLC, DBA Purview). Each reviewer observed the photographic images to confirm each item using the Macintosh Preview application (macOS Monterey, version 12.2.1, Apple Incorporated) so that the location of each object on the image detector was recorded for comparison to the radiographic image at a later date. DICOM and photographic images were assessed by an American College of Veterinary Radiology board-certified veterinary radiologist (SD) and a DVM with postgraduate internship training in radiology (FY).

For statistical analysis, simple percentages were calculated for veterinarians within the social media group that partook in the survey, for item opacity and identifiability when surrounded by air and water, and for the number of objects with inversion of relative opacity in air versus water.

Results

Part 1

The social media platform the online survey was posted on has a membership of 3.9K that
includes veterinarians working in multiple disciplines. The total number of small animal clinicians relative to other disciplines is unknown. Of the clinicians, 362 (9.3%) responded to the social media post, frequently with multiple suggestions, and 68 objects were mentioned greater than equal to 5 times. These 68 objects were selected for the study (Supplementary Table S1).

Part 2
The authors were in complete agreement in reporting whether the structural material of the object was opaque, lucent, heterogeneous (mixed opacities), or obscured in air or water. (Figures 1–4). Objects were divided into the following broad categories for reporting as follows: balls (defined as a spherical object, n = 4; Supplementary Figure S1), food (defined as items designed for consumption when eaten in pieces; 9; Supplementary Figures S2 and S3), fabric (defined as any textile material; 14; Supplementary Figures S4 and S5), wood (3; Supplementary Figure S6), soft plastic (defined as any malleable plastic; 14; Supplementary Figures S7 and S8), hard plastic (defined as any non-malleable plastic; 18; Supplementary Figures S9 and Figure S10), or other (defined as any objects that do not fit any of the previous categories; 6; Supplementary Figure 11).

Findings
All objects evaluated were identifiable when radiographed in air with the exception of the body of the Ziplock bag, although opacity and conspicuousness varied widely and occasionally required extremely careful window width and window level selection for the object to be identified. Many objects became obscured when radiographed in water, as would be expected.
Discussion

Radiographic identification of foreign material requires that the material present has a different opacity to immediately adjacent tissues or material. What was an interesting and somewhat unexpected observation was that some objects, while predominantly opaque in air, became relatively lucent when surrounded by water, or vice versa, permitting their identification in both media but with very different appearances and indicating an “intermediate” opacity that, radiographically, would be considered as “fat.” This is important information for general practitioners to consider when evaluating radiographic images of patients for evidence of dietary indiscretion due to FB ingestion as repositioning of the patient may alter the environment surrounding the FB, causing it to appear starkly different on one projection versus another. There was substantial variation within the broad groups in the relative opacities of objects in air and water. As such on occasions when ingestion of a certain object is observed or suspected by an owner, radiographing a sample of the material in water and air may be very useful in determining whether or not the object may be identifiable at all as well as whether or not the material is likely to alter in relative opacity depending on its environment. On occasions when this is feasible, this will also permit the veterinarian to demonstrate this to the owner, which can only benefit client communication and the decision-making process.

The authors acknowledge certain limitations within this study. One such limitation is that the identification of an object’s shape and size does play a role in interpretation; however, for the purposes of this study, all items used were imaged intact. In clinical cases it may be expected that objects are at least partially chewed, allowing gas to exit and fluid to enter objects, altering their radiographic appearance. Another clinical consideration is that the FB would be compacted within the SI (eg, within a tubular structure), resulting in a possible organized manner such as streaking often seen with fabric material. However, it was decided that imaging of intact objects without any alterations would have the greatest overall value as information pertaining to recognizable objects is more likely to be retained and thus more effectively applied to clinical cases. Similarly, the materials and composition may also play a role in the relative opacity (eg, specific plastic materials, type of wood) and for some materials the degree of water saturation, which could displace internal gas or alter the physical structure of the material (eg, wood or textile material). These considerations would be valuable as a follow-up study; however, in a clinical setting, the specifics pertaining to the FB, even the identity of the FB itself, are often not known, and so only commonly accessible objects were selected without consideration of the composition. Thus, this study provides veterinarians with reference images and radiopacity information in air and water for 68 radiolucent FBs and provides information that may be helpful during times of challenging client communication when a radiolucent FB has been ingested but is not initially identified.

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References


Supplementary Materials

Supplementary materials are posted online at the journal website: avmajournals.avma.org.

Figure 4—Radiographic images of a NERF gun bullet shaft surrounded by air (A) versus water (B), as representative gastrointestinal foreign body reported in the study described. This is an example of a material that is barely radiopaque in air and radiolucent relative to water. Another object that exhibits a similar characteristic includes a foam ear plug.