HOW WE TEACH | Classroom and Laboratory Research Projects

The value of homemade phantoms for training veterinary students in the ultrasonographic detection of radiolucent foreign bodies

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Ingested or penetrating foreign bodies are common in veterinary medicine. When they are radiolucent, these objects become a diagnostic challenge, but they can be investigated sonographically. However, successful object identification depends on the skill of the sonographer. Considering that these cases appear randomly during hospital routines, it is not always possible to train all students to identify them correctly. Therefore, the aim of this study was to produce homemade simulations of radiolucent foreign bodies for veterinary student demonstrations that could be identified sonographically and to evaluate the acceptability, applicability, and usefulness of these simulations according to a visual analog scale questionnaire and subjective questions. For this purpose, object models (a pacifier nipple, a toy ball, a sock, nylon thread, and a mango seed) were designed, produced, and immersed in gelatin. To simulate wood splinters in the integumentary and musculoskeletal system, a piece of meat punctured with a toothpick and ice cream stick splinters were used. The type of phantom had a determinant effect on the visualization (chi-square = 36.528, P < 0.0001) and recognition (chi-square = 18.756, P = 0.0021) capability of the students. All of the students answered that their experience with the models could help in real situations. The student responses to the questionnaire indicated that the project was well accepted, and the participants believed that this experience could be applicable to and useful in veterinary routines.

THE MECHANICAL OBSTRUCTION OF THE GASTROINTESTINAL TRACT by the ingestion of foreign bodies by dogs and cats is widely known in clinical practice (1). It most commonly affects young animals because of their inexperience and curiosity, and this ingestion can manifest as several symptoms, including regurgitation, vomiting, anorexia, hypersalivation, dysphagia, restlessness, and lethargy, depending on the object’s location in the gastrointestinal tract (12). When complete intraluminal obstruction occurs, the proximal bowel distends with gas and liquid (during obstruction, secretion increases, and absorption decreases). Untreated dogs may die dehydrated in 3–4 days, and clinical signs in more distal view, respectively) with posterior acoustic shadowing in the acute phase. In chronic phases, splinters can absorb liquid, becoming less echogenic, and they present a hypoechoic halo, indicating an inflammatory process (10).

Wood splinters appear as hyperechoic interfaces (they are linear or cylindrical in the longitudinal or transverse view, respectively) with posterior acoustic shadowing in the acute phase. In chronic phases, splinters can absorb liquid, becoming less echogenic, and they present a hypoechoic halo, indicating an inflammatory process (10).

Considering that these cases appear randomly during the hospital routine, it is not always possible to train all students to identify them correctly. The Society for Academic Emergency Medicine recommends that simulators be used for ultrasound procedure training (14). Therefore, the development of technical expertise in simulators (training phantoms) is desirable and rec-
ommended, as is the case with “Blue Phantom” in human medicine, but its cost is high (8). Some researchers recommend simulations that employ cheap and easily accessible homemade phantoms as well as gelatin in the construction of training models (5).

Therefore, the aim of this study was to produce homemade phantoms by immersing objects in gelatin to mimic actual cases and to demonstrate the characteristics of these objects upon ultrasound examination. The models were tested by veterinary student volunteers who had already taken the Diagnostic Imaging course, and they answered a questionnaire to evaluate the acceptability, applicability, and utility of these models.

**MATERIALS AND METHODS**

**Model Development**

The following objects were immersed in nontransparent, 17-cm-diameter plastic pots that were filled with unflavored gelatin (the dilution consisted of 24 g of gelatin to 500 ml of water) before solidification (1 object/pot): a pacifier nipple (only the silicone part; Fig. 1A), a rubber toy ball (Fig. 1C), a sock inserted into a pig intestine casing (Fig. 1E), a nylon thread inserted into a pig intestine casing (Fig. 1G), and a mango seed (Fig. 1I). After the gelatin solidified in the refrigerator, the models were covered with a wide rubber band (the type used for exercising) to mimic animal skin and prevent the

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**Fig. 1.** Real (A, C, E, G, and I) and sono-

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examiner from identifying the contents of each pot. To simulate wood splinters within the muscular system, toothpick and ice cream stick splinters were inserted into a piece of meat and used as a model (Fig. 2A). The materials needed to build the models and their cost are shown in Table 1.

**Ultrasound Equipment**

The ultrasound device used here was a My Lab Class C Vet from Esaote with a 6.0- to 18.0-MHz electronic linear transducer (LA435).

**Participants**

The group of veterinary students consisted of 30 volunteers (77% female and 23% male), ~21 yr old, who had already taken the Diagnostic Imaging course but had never performed ultrasound examination for the detection of radiolucent foreign bodies.

**Questionnaire**

The questionnaire consisted of closed questions to be answered with a visual analog scale (VAS) to evaluate the level of difficulty of visualize and recognize the objects in the models and open-ended questions to assess the students’ opinions about this teaching methodology (see example) (4).

Example of objective closed questions:

**Question** 1. Mark an X in the region that best describes the degree of difficulty in visualizing the object.

\[
\begin{array}{c}
\text{Easily visualized} \\
\text{Not visualized}
\end{array}
\]

Example of closed question to be answered with visual analog scale (VAS): Please mark an X along this line in the region that best describes the intensity of your pain over the past week.

\[
\begin{array}{c}
\text{None} \\
\text{Unbearable}
\end{array}
\]

The objective of question 1 was to check the ability of visualizing different objects, whereas the objective of question 2 was to check the ability of recognizing different objects.

**Table 1. Material required to build the 30 phantom models used in the ultrasound training of veterinary students (n = 30)**

<table>
<thead>
<tr>
<th>Material</th>
<th>Unit price (US$)</th>
<th>Amount</th>
<th>Total (US$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nontransparent plastic pot</td>
<td>$1.32</td>
<td>5</td>
<td>$ 6.63</td>
</tr>
<tr>
<td>Unflavored gelatin</td>
<td>$1.10</td>
<td>30</td>
<td>$33.18</td>
</tr>
<tr>
<td>Pacifier nipple</td>
<td>$2.22</td>
<td>1</td>
<td>$ 2.22</td>
</tr>
<tr>
<td>Toy ball</td>
<td>$0.79</td>
<td>1</td>
<td>$ 0.79</td>
</tr>
<tr>
<td>Sock</td>
<td>$1.06</td>
<td>1</td>
<td>$ 1.06</td>
</tr>
<tr>
<td>Nylon thread</td>
<td>$0.92</td>
<td>1</td>
<td>$ 0.92</td>
</tr>
<tr>
<td>Pig intestine casing</td>
<td>$2.65</td>
<td>1</td>
<td>$ 2.65</td>
</tr>
<tr>
<td>Mango seed</td>
<td>$0.23</td>
<td>1</td>
<td>$ 0.23</td>
</tr>
<tr>
<td>Piece of meat</td>
<td>$2.12</td>
<td>1</td>
<td>$ 2.12</td>
</tr>
<tr>
<td>Rubber band</td>
<td>$5.30</td>
<td>1</td>
<td>$ 5.30</td>
</tr>
<tr>
<td>Toothpick</td>
<td>$0.33</td>
<td>1</td>
<td>$ 0.33</td>
</tr>
<tr>
<td>Ice cream stick</td>
<td>$0.26</td>
<td>1</td>
<td>$ 0.26</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td><strong>$55.69</strong></td>
</tr>
</tbody>
</table>

**Statistical Analysis**

The results were tabulated and analyzed with BioEstat version 5.3, which was freely available at the Mamirauá Institute website (9). Values <4 indicated easy object visualization (question 1) and recognition (question 2), and values >4 indicated difficult object visualization (question 1) and recognition (question 2). The students succeeded when answers were <4.

Chi-square test was used to assess the effect of the type of phantom on the success rate of students to visualize (question 1) and to recognize (question 2) the objects. Statistical significance was set at \( P < 0.05 \) for both analyses (6).

**RESULTS AND DISCUSSION**

**Preparation of the Models**

The models were evaluated by the work team without knowledge of their contents. Tests were conducted until the models that most closely resembled the real items were developed based on the instructor’s experience and on data from the

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Fig. 2. Real (A) and ultrasound (B and C) images of a wooden toothpick inserted into muscle used in the ultrasound training of veterinary students (n = 30).

Fig. 3. %Students who found it easy to visualize and to recognize the objects. Seed, mango seed; ball, toy ball; nipple, pacifier nipple; thread, nylon thread; splinter, wooden splinter.
literature. The models were easy and rapid to build, and the cost was low compared with the commercial options (Blue Phantom) (8). On average, each model was prepared within 20 min. The experimental models were kept in the refrigerator for ≤1 wk, and they were used by ≤20 students. The images produced are shown in Figs. 1 and 2.

Answers to the Questionnaire

Objective questions. The answers to objective questions 1 and 2 for each pot were tabulated and used to generate a graphic. The type of phantom had a determinant effect on the visualization (chi-square = 36.528, P < 0.0001) and recognition (chi-square = 18.756, P = 0.0021) capability of the students (Fig. 3).

Subjective questions. When the students were asked whether they believed that their experience with the project could help in a real situation, all of them answered positively. A possible explanation for this positive response is that the students had no previous experience with foreign gastrointestinal bodies, and they acquired greater familiarity with the images, which will be invaluable when they confront similar cases in the clinic.

The objects that were considered the most difficult to identify were the nylon thread, pacifier, mango seed, toy ball, sock, and wood splinter, as reported by 28.2, 23.1, 17.95, 10.25, 10.25, and 10.25% of the participants, respectively. The objects that were considered the easiest to identify were the toy ball, sock, wood splinter, pacifier, nylon thread, and mango seed, as reported by 56.5, 16.7, 10.0, 6.7, 6.7, and 3.4% of the participants, respectively. These findings are in agreement with real cases in our experience in which objects such as toy balls are easier to identify than nylon thread.

When students attempted to guess the object under evaluation, some succeeded and others nearly succeeded. In considering these results and knowing that in real cases the focus of the examination is not the correct identification of the object but the recognition of its presence, we believed that it would be adequate to combine the success and near-success results.

In many cases, the students found it difficult to identify the objects after finding them. However, most students were successful or came very close to an accurate identification when reporting the type of object. The perceived difficulty of identification may have been due to the lack of familiarity of the students with radiolucent foreign bodies. The challenge and the opportunity to describe these objects with confidence led to correct identification in many cases.

In summary, we create models to train veterinary students in the technique of ultrasound scanning and test the models with a group of students. Some objects were easy to see, whereas others were difficult to see, and it was far easier for students to visualize the object than to recognize it. These results are consistent with real practice, where it is far more important to see something (a foreign body) than correctly identify it because the case resolution primarily involves surgery. Simulation-based teaching is supported by the fact that learning medical procedures requires students to acquire cognitive and technical skills. In veterinary medicine, there is growing concern about animal safety; therefore, simulators are effective for training in certain techniques without jeopardizing the life of the animal (14). In addition, when considering the three learning domains (emotional, psychomotor, and cognitive), this simulation provides an opportunity for students to engage in intentional practice to develop psychomotor technical skills that can be performed with enjoyment, and this approach has shown favorable results (14).

In conclusion, the models created here are compatible with actual cases, but not in their entirety, because the images might vary depending on the amount of liquid, gas, and stomach contents as well as inflammation around foreign bodies in muscle tissue found in real practice. However, this study was important because it helped students become familiar with object identification via ultrasound. The student responses to the survey indicated that the project was well accepted, and the students believed that the experience was applicable and useful for routine veterinary diagnostics.

This exercise was a dynamic activity, and it was aimed to delight and engage students in discovering the world of diagnostic imaging. Additionally, students participating in this exercise have an opportunity to explore their understanding of the motility of the gastrointestinal tract (2), the problems caused by the loss of homeostasis due to mechanical obstructions, and how to employ ultrasonographic methods for the diagnosis of radiolucent foreign bodies. Importantly, we include radiolucent foreign bodies in the integumentary and musculoskeletal system. Therefore, the use of this multidisciplinary experience in the Diagnostic Imaging classes will enhance the education experience of students studying basic concepts of gastrointestinal physiology, pathophysiology, and imaging.

GRANTS

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DISCLOSURES

No conflicts of interest, financial or otherwise, are declared by the authors.

AUTHOR CONTRIBUTIONS

C.M.B., É.R.L., and M.C.F.N.S.H. performed experiments; C.M.B., R.H., and M.C.F.N.S.H. analyzed data; C.M.B. and M.C.F.N.S.H. interpreted results of experiments; C.M.B. and M.C.F.N.S.H. prepared figures; C.M.B. and M.C.F.N.S.H. drafted manuscript; C.M.B. and M.C.F.N.S.H. edited and revised manuscript; C.M.B., É.R.L., R.H., and M.C.F.N.S.H. approved final version of manuscript; M.C.F.N.S.H. conception and design of research.

REFERENCES


