Abstract

Knowing how to produce diagnostic radiographs and understanding all of the factors that affect radiographic appearance will help ensure an accurate diagnosis and appropriate treatment. Proper patient positioning helps achieve optimal radiographs while minimizing radiation exposure. Radiation safety is affected by exposure time, distance from the primary beam, and personal shielding. Taking a full series of radiographs is recommended to enhance diagnostic value.
A thorough understanding of the factors that influence diagnostic radiography can help veterinary nurses obtain radiographs that allow for both accurate diagnoses and proper treatment plans for patients. Patient positioning is an important factor that can drastically affect radiographic interpretation. A radiograph of a poorly positioned patient can lead to an inaccurate diagnosis and, consequently, unsuccessful treatment. The veterinary team must, therefore, work together to ensure that each radiograph is truly representative of the patient.

In part 1 of this series, the veterinary team will review the value of patient positioning for thoracic and abdominal radiographs. In part 2, scheduled to be published in the Today’s Veterinary Nurse Fall 2023 issue, the veterinary team will learn to use a diagnostic imaging quality checklist to aid with proper diagnostic interpretation and patient treatment.

**X-RAY PROPERTIES**

German physicist Wilhelm Röntgen accidentally discovered x-rays in 1895 while working with a covered cathode tube, which fluoresced a screen on the opposite side of his laboratory. After more experiments and numerous hours, he discovered a “new ray” that had very specific properties. He named this unknown and mysterious new type of radiation the “x-ray.”

Today, we know that x-rays:

- are nonparticulate rays that fall between gamma and ultraviolet rays on the electromagnetic spectrum
- are highly penetrating invisible rays that form electromagnetic radiation
- are electrically neutral, not affected by electric or magnetic fields
- produce a wide variety of energies and wavelengths
- release heat as they pass through matter
- travel in straight lines
- travel at the speed of light in a vacuum
- ionize matter
- cause fluorescence of specific crystals
- are not focused by a lens
- affect photographic film
- create chemical and biological changes in matter due to ionization and excitation
- produce secondary and scatter radiation

These properties make them useful as well as dangerous. Radiographs should be ordered by the veterinarian only when medically necessary. X-rays have a short wavelength and are emitted at high frequency, which means that they contain a lot of energy and can penetrate through most matter, including soft tissue, fat, and air. Denser materials such as metal and bone absorb more x-rays, while less dense areas allow all x-rays to pass through. The variations in tissue densities, and therefore the number of x-rays transmitted, determine the radiographic opacities or distinction of structures.

**RADIATION SAFETY**

Everyone must be their own advocate when it comes to radiation safety. Understanding and following radiation safety guidelines will help protect the veterinary team and patients from the potential harmful effects of ionizing radiation. The following 3 factors will help ensure radiation safety in the veterinary clinic: time, distance, and shielding. Always use the shortest exposure time to decrease the amount of scatter radiation (deflected primary beam x-rays) delivered to the patient and the veterinary team. Take the time to properly position the patient to minimize the number of times you need to retake the images. Use alternative positioning restraint devices (e.g., tape, sandbags, foam wedges) on patients to minimize the number of

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**Take-Home Points**

- Follow the ALARA (as low as reasonably achievable) principle.
- Use sedation when necessary.
- Understand radiographic terminology.
- Never take just 1 view.
- Know that positioning matters.
- Take the extra time for proper positioning to reduce the need for retakes.
- For the best diagnostic results, take the full radiographic series.
Use the lowest possible radiation dose needed to obtain diagnostic images by following an appropriately calibrated technique chart.³

personnel needed in the room during x-ray exposure (FIGURES 1 AND 2). If team members must remain in the room, they should keep as far away from the primary beam as possible and wear the appropriate personal protective equipment (PPE).³ Radiology PPE requirements vary by state. Best practice suggests that radiology PPE should include a lead gown (containing 0.5 mm of lead) that wraps half-way around the wearer and covers from the thyroid to the knees, a lead thyroid shield, and full coverage (360 degrees) lead gloves (FIGURE 3).³ Use the lowest possible radiation dose needed to obtain diagnostic images by following an appropriately calibrated technique chart.³

The ALARA (as low as reasonably achievable) principle involves taking steps to reduce the amount of radiation exposure to the lowest level possible while still achieving a high-quality diagnostic study.³ Following radiation safety guidelines and best practices will minimize the harmful effects of ionizing radiation to the veterinary team and the patient.

DIRECTIONAL TERMINOLOGY

The nomenclature for radiographic projections has been standardized by the American College of Veterinary Radiology.⁴ Names of radiographic views are based on the trajectory of the x-ray beam as it travels from the tube, through the patient, and to the recording receptor.

The name of the view begins with the primary beam’s point of entry and ends with its point of exit, relative to the position of the patient.⁴ For example, when the patient is in dorsal recumbency, the radiographic view name will be ventrodorsal for an abdominal or thoracic series because the x-ray beam enters the patient’s ventral surface and exits the patient’s dorsal surface.
The nomenclature for lateral thoracic and abdominal views in small animal radiography, however, is abbreviated to just the point of exit of the primary beam. For example, a left-right lateral view of the patient’s thorax or abdomen is abbreviated to describe the beam’s point of exit as the right lateral side of the patient.

Because each area of interest (AOI) has many names, the entire veterinary team should be familiar with proper anatomical and directional terminology to ensure correct radiographic views are achieved (TABLE 1 AND FIGURE 4). One should also be cautious; the commonly used abbreviation is not always correct.

To ensure that a proper diagnosis can be made, best practice is to take at least 2 orthogonal views (i.e., 90 degrees from each other) of each AOI. Radiographs are 2-dimensional representations of 3-dimensional anatomy, and often relevant anatomical structures are superimposed with or overlap each other, which can be challenging when assessing the AOI. Having at least 1 orthogonal view enables visualization of the patient in another position and helps with localization of structures or lesions to facilitate a thorough and accurate radiographic interpretation.

### TABLE 1 Directional Terminology and Abbreviations

<table>
<thead>
<tr>
<th>TERM</th>
<th>ABBREVIATION</th>
<th>DEFINITION</th>
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<tbody>
<tr>
<td>Rostral</td>
<td>R</td>
<td>Toward the nares</td>
</tr>
<tr>
<td>Cranial</td>
<td>Cr</td>
<td>Toward the head</td>
</tr>
<tr>
<td>Caudal</td>
<td>Cd</td>
<td>Away from the head</td>
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<tr>
<td>Dorsal</td>
<td>D</td>
<td>The upper or back area</td>
</tr>
<tr>
<td>Ventral</td>
<td>V</td>
<td>The lower or underside area</td>
</tr>
<tr>
<td>Lateral</td>
<td>L</td>
<td>Away from midline</td>
</tr>
<tr>
<td>Medial</td>
<td>M</td>
<td>Toward midline</td>
</tr>
<tr>
<td>Palmar</td>
<td>Pa</td>
<td>Caudal aspect of the forelimb, distal to the carpus</td>
</tr>
<tr>
<td>Plantar</td>
<td>Pl</td>
<td>Caudal aspect of the hindlimb, distal to the tarsus</td>
</tr>
<tr>
<td>Right</td>
<td>Rt</td>
<td>Opposite of left side</td>
</tr>
<tr>
<td>Left</td>
<td>Le</td>
<td>Opposite of right side</td>
</tr>
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</table>

Note that when nomenclature is abbreviated, the abbreviations can be misinterpreted. For example, L can mean left or lateral and R can mean right or rostral.

**RADIOGRAPHIC SOFT TISSUE STUDIES**

To ensure finished radiographs do not contain radiographic artifacts, distortions, or inaccuracies, veterinary nurses need to be familiar with radiographic studies for each AOI: abdominal and thoracic.

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**FIGURE 4.** Directional terminology.
Abdominal Radiographs

Abdominal radiographs are helpful for diagnosing and monitoring conditions that affect the abdominal organs. These radiographs enable the veterinarian to visualize the size, shape, and position of the organs within the abdomen and to identify any abnormalities (e.g., masses, gastrointestinal [GI] foreign objects). To ensure a proper radiographic diagnosis, the full abdominal cavity must be included on the image. The cranial point of the abdominal cavity is the cranial tip of the liver and adjacent diaphragm, and the caudal point is the greater trochanter of the femur.  

To ensure a proper radiographic diagnosis, the full abdominal cavity must be included on the image. The anatomical landmarks coincide with the palpable landmarks of 3 ribs cranial to the xiphoid (FIGURE 5) and the bony prominence of the proximal femur. The L technique is a way of identifying the landmarks of the cranial abdomen. For this technique, place the tip of your thumb on the caudal edge of the xiphoid and collimate (narrow) the x-ray beam to the pointer finger, which will indicate the cranial abdominal landmark (tip of the liver). Abdominal radiographs should be taken during expiration, when the diaphragm is pulled cranially, increasing the separation of, and therefore creating greater differentiation between, the abdominal organs (FIGURE 6).  

Best practice for abdominal radiographs is to take 3 views: right lateral, left lateral, and ventrodorsal. These views are necessary because gas within the GI tract may obscure the organs and make diagnosis difficult.  

FIGURE 5. Full radiographic exposure of the abdomen. The palpable abdominal landmarks help ensure that the full abdominal cavity is included in the finished radiograph, from 3 rib spaces cranial to the xiphoid, including the full liver (yellow line), and caudally to the greater trochanter (yellow arrow).

FIGURE 6. Abdominal radiograph of a dog taken during expiration: diaphragm cranial (yellow line).

FIGURE 7. Full radiographic exposure of the thorax. To be sure to get the full thoracic cavity in the image, palpate the thoracic inlet (manubrium) cranially and the attachment of the last rib (T-13) caudally and collimate the x-ray beam to the area of interest.

FIGURE 8. Thoracic radiograph of a dog taken during inspiration: diaphragm caudal (yellow line).
tract (particularly the stomach) will shift between recumbency positions, thereby highlighting different portions of the anatomy. The right lateral view highlights the left-sided (non-gravity dependent) gastric fundus and body. The right lateral view is also the view of choice for patients with gastric dilation and volvulus. The left lateral view highlights the pyloric antrum, pyloric canal, and duodenum, which is useful for identifying foreign material. The ventrodorsal view is preferable to the dorsoventral view because it creates less superimposition of the abdominal structures.

Thoracic Radiographs
Thoracic radiographs are used to diagnose problems of the pulmonary system (e.g., infections, masses, congenital abnormalities) or cardiovascular system (e.g., cardiac enlargement, congenital abnormalities).

Proper diagnosis can be made only if the full thoracic cavity is evaluated. Thoracic collimation must include the thoracic inlet cranially to the last rib caudally. The palpable cranial landmark is the manubrium and the palpable caudal landmark is the curve of the last rib. The corresponding visual landmarks on the finished radiograph are the cranial point of the manubrium and the first lumbar vertebra (FIGURE 7). With few exceptions, thoracic radiographs should be taken during peak inspiration, when the diaphragm is pulled caudally and the lungs are maximally inflated (FIGURE 8), which enables evaluation of the caudoventral lung field between the heart and the liver.

To ensure a proper radiographic diagnosis, a full series of thoracic cavity images should be evaluated. The 4 suggested thoracic views are left lateral, right lateral, ventrodorsal, and dorsoventral. The right lateral view highlights the left lung lobes due to atelectasis or collapsing of the dependent right lung lobes, caused by gravity and the body’s weight on the down side. The left lateral view conversely highlights the right lobes. The ventrodorsal view is taken to fully evaluate both the right and left lung lobes and to provide an orthogonal view to localize pathology. For cardiovascular evaluation, the dorsoventral view is typically added to the series to aid with visualization of the vessels of the caudal lung lobes. Together these views help the veterinarian differentiate abnormalities within the thoracic cavity.

SUMMARY
Diagnostic radiographs of patients require planning, teamwork, and patience. One should always practice ALARA and hands-free radiography whenever possible. All veterinary team members in the radiology room must wear PPE during the x-ray exposure period. Using best-practice radiographic positioning skills will help the veterinarian arrive at appropriate diagnoses and treatment plans for patients.

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Liane is a 2003 graduate of the veterinary technology program at Purdue University, where she earned an associate and a bachelor’s of applied science degree with a minor in organizational leadership and supervision. She recently earned a master’s degree in higher education with Purdue University Global. Liane is a senior instructional technologist with specialties in radiology, dentistry, and learner-centered classrooms. Liane has been teaching since 2008 and is always evaluating how to improve the students’ learning experience. She has received awards for excellence in teaching from Purdue University and Elanco Animal Health in 2011 and 2018. Liane stays busy by spending her evenings with her husband and 2 sons on their small hobby farm in Indiana, home to horses, dogs, cats, and a donkey named Shrek!