Small Animal THORACIC Radiography

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This article is the first in a series of articles that will discuss various radiographic positions and techniques. The veterinary technician plays a critical role in the development and maintenance of a radiographic program at a veterinary practice. Thus, it is the responsibility of the technician to be familiar with the basics of:

• Anatomy and positioning
• Technique and image formation
• Quality control of images made within the radiographic suite.

The purpose of this article is to review the 3 basic components of creating high-quality thoracic radiographs of the dog and cat, including positioning, technique, and quality control of the final images.

With advances in imaging technology (computed and digital radiography), errors in technique are less common; however, if anatomy is not appropriately collimated and positioning is inadequate, all imaging studies can be rendered nondiagnostic.

A routine thoracic radiographic study includes 3 projections: right and left lateral images and a ventrodorsal (VD) or dorsoventral (DV) image.

RADIOPHGRAPHY LINGO

• Anode: An electrically positive terminal of a radiographic tube that emits x-rays from the point of impact of the electron stream from the cathode.
• Cathode: The negative side of the radiographic tube where electrons are emitted; it consists of the focusing cup and filaments.
• Cassette/detector plate: A light-proof housing for radiology film, containing front and back intensifying screens between which the film is placed.
• Collimation: This term refers to the process of adjusting an optical instrument so that the x-ray image includes the area of interest.
• Milliampere x second (mAs): Describes the exposure setting of a radiology machine and determines the radiographic density. mAs is calculated by:
  \[ mA \text{ (station number setting)} \times \text{time (setting)} = \text{mAs} \]
  (eg, 100 mA \times 0.10 \text{ sec} = 10 \text{ mAs})
• Peak kilovoltage (kVp): The maximum voltage applied across an radiographic tube, which controls the x-ray penetration of the subject being imaged.
• Peak inspiration: Exposing film at peak inspiration maximizes the air in the lungs and the subject contrast within the thorax.
From a technical standpoint, thoracic radiographic exposure should be obtained using a high peak kilovoltage (kVp) (80–120 kVp) and low milliampere × second (mAs) (1–5 mAs) technique. This technique allows for latitude (long gray scale) images, which are important when evaluating the structures of the thorax.

Several examples would include:

- 82 kVp at 2 mAs for 15-cm dog for analog film (400 speed system) or
- 80 kVp at 5 mAs for a 15-cm dog for a digital plate radiographic system.

For any dog measuring 15 cm or greater (measured at the liver or thickest part of the thorax), a grid (8:1, 110 lines per inch) should be used. Grids are available from most radiology manufacturers and a grid tray comes with all radiology units. For almost all radiology units, a grid is sold with the radiographic machine and table.

The rotor for the anode and the low-voltage circuit for the focusing cup/electrons of the cathode should be coupled to a foot or hand switch so that accurate timing of the exposure at peak inspiration can be made (Table).

**MEOW MEETS BARK: DIFFERENCES BETWEEN CATS & DOGS**

Even though the same anatomic landmarks are used in the dog and cat, there are some key differences when it comes to quality control of the thoracic image.

- In the cat, the caudal dorsal lung margins (diaphragmatic crura) will extend beyond the 13th thoracic vertebra, which will not be true in the dog (T10-11).
- In addition, while the thoracic limbs in the cat are easier to pull forward, cats may resent lateral recumbency positioning. Take your time and allow the patient to calm down rather than rushing through a study.

**Figure 1.** (A) Dog in right lateral recumbency with thoracic limbs pulled cranially. See text for anatomic boundaries of collimated thorax. (B) Right lateral thoracic radiograph of dog in Figure 2A; notice the cranial location of the thoracic limbs relative to the thoracic inlet.

**Figure 2.** (A) Dog in left lateral recumbency with thoracic limbs pulled cranially. See text for anatomic boundaries of collimated thorax. (B) Left lateral thoracic radiograph of the dog in Figure 2A; notice the cranial location of the thoracic limbs relative to the thoracic inlet.
Routine Views

Lateral Images

Positioning

For a right and left lateral image, the patient is positioned on the table with the dependent side down and marked with a lead marker to indicate the dependent side in the collimated area as right (R) or left (L).

1. The thoracic limbs should be taped together evenly and pulled cranially so that the elbows and tissues of the triceps muscle are not superimposed over the cranial thorax (Figures 1 and 2).

2. To determine whether or not a patient is aligned in a lateral position and parallel to the table, use an imaginary plane through the sternum and dorsally through the spinous processes of the thoracic vertebrae.

3. A foam wedge may be placed under the elbows in order to maintain laterality of the patient (sternum and vertebrae are equidistant to the table).

4. In order to keep the patient in a true lateral position, the pelvic limbs are also taped and pulled caudally.

Collimation

To set the collimation for the thoracic anatomic boundaries of a lateral image (right or left):

- **Vertical Line of the Collimation Light:** Palpate the caudal border of the scapula dorsally and place the vertical line at this point. This allows for the cardiac silhouette to be in the center of the image, giving a true representation of the cardiac size and shape.

- **Horizontal Line of the Collimation Light:** The horizontal line should be placed in an imaginary plane so as to bisect the thoracic cavity evenly between dorsal and ventral. Palpate the manubrium and place the cranial edge of the collimation beam at the cranial edge of the manubrium; this places the caudal edge of the beam at the level of the 13th rib head and T13.

Remember to always include the sternum of the patient so as not to exclude vital anatomy:

- **In large-breed dogs,** it may be necessary to exclude the spinous processes. A separate image might be necessary if indicated.

- **In deep-chested breeds,** such as Great Danes, Doberman pinschers, or mastiffs, the cassette/detector plate may be turned vertically to encompass the entire thoracic cavity in the dorsal and ventral plane.

- Turning the cassette/detector plate vertically does not allow for the entire thorax to be included; therefore, cranial and caudal views need to be taken, for completeness.

### Table: How to Determine Whether Radiograph Was Taken at Peak Inspiration

<table>
<thead>
<tr>
<th>Patient Size</th>
<th>Lateral</th>
<th>Ventrodorsal/Dorsoventral</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small-breed dogs</td>
<td>Diaphragmatic crura at level of T10</td>
<td>Costophrenic angle (Figure 4) at level</td>
</tr>
<tr>
<td>(hardest to</td>
<td>(minimum); preferably at T12</td>
<td>of 10th rib (minimum); preferably at 12th</td>
</tr>
<tr>
<td>consistently catch</td>
<td>Cupula at T8</td>
<td>rib</td>
</tr>
<tr>
<td>on peak inspiration)</td>
<td>May see overlap between the borders</td>
<td>Diaphragmatic cupula (center) at T8</td>
</tr>
<tr>
<td></td>
<td>of the cardiac silhouette and</td>
<td></td>
</tr>
<tr>
<td></td>
<td>diaphragm</td>
<td></td>
</tr>
<tr>
<td>Medium-breed dogs</td>
<td>Diaphragmatic crura at T12–T13 (cats,</td>
<td>Costophrenic angle located at T10–T11</td>
</tr>
<tr>
<td>Large-breed dogs</td>
<td>T1–L1)</td>
<td></td>
</tr>
<tr>
<td>Cats</td>
<td>Cupula at T10</td>
<td>Diaphragmatic cupula at T10</td>
</tr>
<tr>
<td></td>
<td>Separation of heart and diaphragm</td>
<td>Separation of heart and diaphragm</td>
</tr>
</tbody>
</table>

**Figure 3.** (A) Dog in ventrodorsal recumbency with thoracic limbs taped and pulled cranially. The light marks the cranial border of the image that is collimated to the level just cranial to the thoracic inlet. (B) Ventrodorsal lateral thoracic radiograph of the dog in Figure 3A; notice the cranial location of the thoracic limbs relative to the thoracic inlet.
Ventrodorsal Images

**Positioning**

For the ventrodorsal view, the patient should be placed in dorsal recumbency.

1. Using a V-trough helps keep the patient's spine and sternum aligned.
2. The thoracic limbs are taped together evenly and pulled forward with the patient's muzzle placed between the limbs (Figure 3, page 47).
3. The pelvic limbs are pulled caudally and secured. The technique described in Step 2 does not work well for:
   - **Brachycephalic breeds**, such as English bulldogs or pugs, that might have issues with upper airway disease or obstruction
   - **Chondrodystrophic breeds**, such as dachshunds or basset hounds, because they are physically unable to do so.

When presented with these types of patients ensure that the head and neck are straight out in front of the body and not obliqued to the left or right.

**Collimation**

To set collimation for the ventrodorsal view, the landmarks are the same as the lateral projection:

- **Vertical Line of the Collimator Light**: Place the vertical line at the caudal border of the scapula. This allows the cardiac silhouette to be in the center of the image.

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**Figure 4.** (A) Dog in dorsoventral recumbency with thoracic limbs taped and pulled cranially. The light marks the cranial border of the image that is collimated to the level just cranial to the thoracic inlet. (B) Dorsoventral thoracic radiograph of the dog in Figure 4A; notice the cranial location of the thoracic limbs relative to the thoracic inlet.

**Figure 5.** A conventional ventrodorsal projection (with the legs pulled forward); notice that the caudal portion of the scapulae are superimposed over the cranial lung fields.

**Figure 6.** (A) Dog in ventrodorsal recumbency with the thoracic limbs taped in the humanoid position, down along the dog’s side. This position results in the scapulae rotating externally and cranially instead of being superimposed over the cranial lung lobes. The light marks the cranial border of the image that is collimated to the level just cranial to the thoracic inlet. (B) Ventrodorsal thoracic radiograph corresponding to the dog in Figure 6A; notice the externally rotated scapulae (arrows) and lack of superimposition over the cranial lung fields (compared with Figure 5).
• **Horizontal Line of the Collimator Light**: The horizontal line should be placed directly over the sternum so as to bisect the thoracic cavity from left and right lateral. Palpate and place the edge of the collimation beam at the cranial edge of the manubrium; this places the caudal edge of the beam to the 13th rib head at the level of the thoracic spine.

• **In large-breed dogs** (e.g., Great Dane), it will be necessary to take a cranial and caudal projection.

1. The patient is placed dorsally and the thoracic limbs are taped separately and pulled caudally to lie adjacent to the lateral body wall (Figure 6).
2. The landmarks will be the same as the ventrodorsal view.

**Horizontal Beam Projections**

Horizontal beam sternal or dorsal projections are used for assessing the cranial mediastinum or fluid/air distribution within the thoracic cavity.

These views are dependent on the ability of the radiology machine tube to be manipulated in a 90° angle. In addition, using a positioning trough makes these views easier to obtain.

1. **To determine fluid or free air distribution**, position the patient as if performing a ventrodorsal view (i.e., dorsal recumbency).
2. **To visualize the cranial mediastinum**, position the patient as if performing a dorsoventral view.
3. Place the cassette/detector against the lateral body wall, making sure to mark the dependent side L or R.
4. The landmarks are the same as the lateral projection (Figure 7).

**Quality Control**

For quality control of any diagnostic image, keep a simple 4-step approach in mind:

1. Determine if the technique is appropriate.
2. Ascertain if the appropriate anatomy is present within the image.
3. Check the positioning for laterality and straightness.
4. Determine if projection was taken at peak of inspiration.

**Dorsoventral Images**

**Positioning & Collimation**

The dorsoventral radiograph is one of the hardest radiographs to position consistently. The dorsoventral image best visualizes lesions in the caudodorsal lung lobes.

1. The dog is either in:
   • Ventral recumbency without the legs taped, resulting in a “sphinx” position (Figure 4) or
   • A frog-leg position (pelvic limbs).
   The comfort of the patient is of utmost importance.
2. The thoracic limbs are pulled cranial and abducted.
3. The anatomic landmarks are the same as for a ventrodorsal image.

**ADDITIONAL VIEWS**

**Humanoid Projection**

In a conventional ventrodorsal projection (with the thoracic limbs pulled cranial), the caudal portion of the scapulae are superimposed over the cranial lung fields (Figure 5). The humanoid projection obtains no summation of the scapula with the cranial lung fields.

**POSITIONING VETERINARY PATIENTS**

The following positioning devices can be used to help position patients and reduce staff members’ exposure to radiation:

• Elastic tape
• Plastic tongs
• Positioning trough (foam or plastic)
• Rope and cleats along the side of the table
• Sandbags (particularly long snake-like sand bags)

Patient in lateral recumbency showing correct use of tape and sandbags; the dog is muzzled due to its history of biting (see Dog Bites: Protecting Your Staff & Clients, page 66)
Technique & Anatomy
Given that the desired technique has been attained, make sure that the appropriate anatomy is included. The laterals, ventrodorsal, dorsoventral, humanoid, and horizontal beam projections should:

• Extend from the cranial margin of the manubrium to the caudodorsal margin of the lung margin/diaphragmatic crus.
• Not exclude the sternum on the lateral or lateral aspect of the ribs on the ventrodorsal view.

Positioning
If the technique exceeds quality standards and the correct anatomy is present, check patient positioning.

• For the lateral projection, use superimposition of the rib heads throughout the thoracic spine to determine if a patient is in a true lateral position (Figures 1B and 2B).

• For the ventrodorsal projection, each thoracic spinous process is viewed end-on and has a distinct diamond or tear-dropped shape without the ability to see the sternum and the thoracic vertebrae as separate structures.

• For the dorsoventral projection, positioning is similar to the ventrodorsal in that the thoracic spinous process is viewed end-on and has a distinct diamond or tear-dropped shape without the ability to see the sternum and the thoracic vertebrae as separate structures.

Peak Inspiration for Image Acquisition
Finally, determine if the projection was taken at the peak of inspiration:

• For the lateral view, the caudal aspect of the cardiac silhouette will not be superimposed over the diaphragm and there is an upside down triangle that is visualized using the caudal vena cava, diaphragm, and caudal border of the heart as the margins.
• For the ventrodorsal view, the cupola or central portion of the diaphragm will be separated from the caudal border of the cardiac silhouette. The lateral margins of the diaphragmatic crura will come to the 11th or 12th intercostal space and the right and left cranial lung lobes will extend to the level of the thoracic inlet.
• The exception to these rules is the extremely obese patient that cannot take a deep inspiratory breath.

SUMMARY
Thoracic radiographs are often used as a first-line test for possible intrathoracic disease. High-quality, correctly positioned radiographs are required in order to provide as accurate an assessment as possible.

In addition, a 3-view thorax (right lateral, left lateral, and dorsoventral or ventrodorsal view) is considered the standard of care in veterinary medicine. Following a consistent, repeatable pattern for obtaining thoracic radiographs ensures that the quality of the images will always be diagnostic.

Suggested Reading