Avian Necropsy

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Photo credits:
Western Grebe necropsy photos Guthrum Purdin DVM
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Directions are very important when describing where an abnormality is located. The terms anterior and posterior are rarely used in veterinary medicine except within the eye. Dorsal = spine side of animal, ventral = belly side, medial = towards midline, lateral = away from midline, proximal = closer to point of origin, distal = more distant from point of origin, cranial = towards the head, caudal = towards the tail. On the head, use rostral = towards bill tip, and caudal = toward the back of the head. Describe abnormalities based on size, shape, color, texture, depth, and chronicity. For example, saying “a 4 x 2 x 1 cm wound is filled with gritty tan caseous material at the lateral left thigh” is more informative than saying “wound on leg”!

When handling live or dead birds, pay close attention to comparative anatomy features, such as nostril location (or lack thereof), because it has critical implications for proper care and handling!
For reference, here’s a “typical” avian skeleton, although features vary significantly between genera and species. Unlike mammals, most birds have light, “pneumatized” bones with central open spaces. These hollow, lighter bones enable flight and aid respiration, but can be an important consideration for treating bone fractures and for systemic spread of disease. One part of the avian skeleton that can facilitate species identification from skeletonized carcasses is the sternum with its prominent keel. Another is the skull.

Personal Protective Equipment (PPE) is required when performing necropsies (At minimum, gloves, eye protection and an apron). Wear goggles if you do not wear glasses. Dedicated necropsy clothing such as scrubs are ideal. Wear waterproof, disinfectable boots or shoes to control pathogen spread. Surgical or dust masks can protect against splashes, but cannot prevent pathogen inhalation. If aerosolized pathogens might be present, use an N-95 rated mask at minimum, and make sure it is well-fitted to your face. Always follow the PPE requirements of the facility where you are working, as hazards may vary by event.

Begin with a thorough physical examination. Many reasons for the animal dying or being euthanized may be related to obvious problems, such as ‘missing wing’ or ‘arrow through head’. Prosectors can feel embarrassed when they miss obvious causes of death. Look for plumage abnormalities, oil or other surface materials. For non-oiled birds, be sure to evaluate plumage condition for stress marks (signs of a problem during feather growth), algae, broken, stripped, missing, or molting feathers, or other plumage problems.
Above are examples of excessive wear of the tail and wing feathers.
Stress lines (aka stress bars or fault bars) on the tail feathers. Feathers require nutrients to grow normally. If nutrition or health are compromised while the feathers are developing, stress bars can result. (http://www.windycityparrot.com/What-are-feather-stress-bars-Does-your-bird-have-them_b_176.html)

Aquatic birds such as loons and grebes that don’t normally spend much time on land are prone to developing skin problems on their legs, feet and keel post-stranding. Above is an example of pressure necrosis of the skin overlying the keel on the ventral chest.
As part of your examination, **always verify that any preliminary species identification is correct.** Get help if you need it. Can you identify the two birds above? Are they the same species?
Growth of **algae or diatoms** is relatively common on seabird feathers, and can be confused with oil.

A common murre that died due to surface **petroleum contamination** (oiling).
External features to note during avian necropsy: Presence or absence of a brood patch (featherless area on ventral breast that aids incubation in some species), or bands, tags or other external markings.
Carefully document (describe and photograph) any signs of human-associated lesions: Above and bottom: Fishing line entanglement. Right: This pelican’s upper bill was deliberately cut in half. Save as evidence any hooks, lines, netting, bullets, etc. Report suspect cases to state and federal law enforcement!
Examples of artifacts that you might encounter: Attached barnacles on a bird that was recovered from the water. Decomposing aluminum foil on a bird from a spill event that was wrapped in aluminum foil and stored in the freezer for a long time. This is why storage of oiled birds in aluminum foil is not recommended!
Examine the whole bird. Before starting dissection, palpate and assess nutritional condition in the same way that you would during physical examination of a live bird. What was your bird’s nutritional status at the time of death? Palpate bones and joints and feel their ranges of motion. **Check for asymmetry, swelling, crepitus or other abnormalities.** In the photo at right, which joints are normal and which are abnormal?

Some visually subtle problems can be more serious than they look. The left-hand bird has a small area of necrotic (dead) skin that is adherent to underlying bone. These lesions can be tough to spot, because many seabirds have black leg skin, especially when oil is present. Oil may cause skin burns that can look like this on scaly skin, or as reddened inflamed-looking areas on feathered skin. Skin burns are commonly found at the hocks and under the wings in the axillary area (wingpit) when the bird is oiled there. If you find a significant lesion, cut across it and note the character of the tissue deep to the lesion. Does it penetrate a joint? Is there necrotic muscle or a damaged tendon? Is the lesion significant enough to be the reason for death or euthanasia? More chronic examples with severe tissue swelling are shown at right.
Both feet above are from the same bird. Why do they look so different?
To begin the dissection, wet down the ventral midline of the bird with soapy water.

Although feathers appear to evenly cover most birds, they actually grow in specific feather tracts called pterylae, while adjacent featherless areas of the skin are called apteria. Find the apteria that runs down the ventral midline of most bird species. Part the wet feathers along this line over the keel and cut the skin along this line so you can avoid creating a mess of loose feathers that can get in your way of seeing things. The picture at right shows the inner skin surface of an emaciated seabird. The skin of the ventral breast has been reflected laterally to show the lateral pterylae (marked by “bumpy”-appearing subcutis due to presence of feather follicles) and the midline apteria (curved, smooth pale stripe of subcutis at bottom center).
Pterylae and apteria can be easier to see after wetting the feathers of non-aquatic birds, like this barn owl.
Don't forget to assess and record signs of moult! A pin or blood feather is a developing feather. Above are pin feathers on the wing of a nene goose. Can you tell if this nene is a growing chick or an older bird? (http://pacificislandparks.com/2014/01/22/meet-the-next-generation-of-nene/).

Assessing moult of the smaller contour feathers covering the body is easiest to do on the inner surface of the skin, where growing pin feathers are typically darkly pigmented. Note the peterylae and apteria.
Cut straight down the ventral midline apteria with a scalpel, then reach your fingers between the skin and muscle and pull the skin laterally to separate it back to the shoulder joints. Note how few feathers have escaped from the skin. By a combination of pulling, ripping and cutting, extend this opening to the vent caudally, and past the clavicles cranially.
Extend the opening up the neck all the way to the mandibles, exposing the trachea, esophagus, and neck muscles. **Check your assessment of nutritional condition based on external palpation**—How close were you? The bird at left was euthanized because it was blind. It was in **excellent nutritional condition** at the time of death, as shown by the thick subcutaneous fat and rounded, convex pectoral muscles. Compare with the **emaciated bird** on the right. There is **no subcutaneous fat** and the pectoral musculature is concave, with a markedly prominent keel.

**Assessing body condition**


The Van Franeker scoring system for avian body (nutritional) condition uses a 0-3 scale for SQ fat, intestinal fat and pectoral muscle. The value for each of these three scales is summed to provide a 0-9 scale reflecting the full nutritional range, from severe emaciation, to plump health.
Here’s another view of the **ventral midline cut** that extends **from the clavicle** (aka wishbone) **to the ventral base of the bill** along the entire length of the neck.

This is a good time to look for the **thymus**, which in birds forms a **linear to multi-nodular band of pale pink to light tan tissue** along either side of the **neck**. It is **often more prominent** along the right side of the **neck**. This tissue is only seen in young birds, so it’s a **sure sign of younger age**. What is the function of the **thymus**, can you remember?
Insert a gavage tube as if you were going to tube feed the bird. See how delicate the esophagus tissue is? Where is the tip of the tube located when you have it in position to feed? Some species are more prone to esophageal perforation during tubing, especially ruddy ducks. If one is available, see if you can see why that might be.

Open the abdominal body wall without piercing the intestines or cloaca. Scissors often work best for most dissection rather than using a scalpel.
Continue opening the body wall sufficient to **expose the organs as much as possible**. In Common murre this space is very small because their keel is enormous. **Examine visible air sacs and look cranially under the ribs** to look for abnormalities before removing the sternum, lest you cut through significant lesions without noticing. If you find an unexpected abnormality, let the instructor know before you proceed.

**Cut through the pectoral muscles to expose the ribs** along a line from the high point of the clavicle curvature to the lateral rib cage. This will make cutting the sternal plate off easier.
Cut along the ribs where you exposed them in a **straight line between the liver and the clavicle, running just above the lungs**. You can use blunt-sharp scissors for much the ribs in most birds, but will need poultry shears or rib snippers for the coracoid and clavicles. Avoid cutting or smashing any organs.

**Cutting through the ribs to remove the sternum**, being careful to not damage organs while cutting.
Left: Example of proper depth sternum removal to minimize organ damage. Instruments are indicating the proper angle to remove the sternum without organ damage. Right: Diagram of the same region.

As you cut, **lift the sternum** and **examine the air sacs** before cutting. Compare the **clear and very thin, normal air sacs at left** with the thickened and opaque air sacs of a **bird with aspergillosis at right**. Cut through the muscles around the clavicles and coracoid if necessary to free the keel. Sever any attachments between the liver, heart and sternum and lift it off.
The air sacs of this cormorant at left contain some tiny white spots. What the heck are those? For a hint, look at the microscopic image of the same air sac on the right.

Now you can observe and identify the organs of the **coelomic cavity** (because birds don’t have a diaphragm, they have a single coelomic cavity, vs the chest and abdominal cavity of mammals). It's always
a good idea to **photograph** the organs in place at this stage, **identify the organs and scan for any abnormalities**. Also it’s important to **collect samples for bacterial or fungal culture** or other sensitive tests **prior to handling and contaminating the tissues**. Find the heart, liver, intestines. Aquatic birds have a gall bladder that will look like a green balloon peeking out from under the liver. Lift the liver from side to side to examine the sides of the body cavity for any lesions. Find the kidneys, gonads and adrenal glands.

**Most birds** have **bilateral testes (testicles)**, but **only one ovary**, located at the **cranial end of the left kidney**. It is commonly found on top of the **adrenal gland**, which is often light orange and vaguely triangular. Testicles in **non-breeding birds** are often **very small**. In some species the testicles may be half dark and half light-colored, while for others they may be creamy tan. In many birds the testes are located almost on top of the adrenal gland, while in others they are located a bit farther away. In very young birds it may be difficult to see the gonads at all.
As with males the **ovary and uterus** of females **varies greatly in size** based on each animal’s state of maturity, as well as marked seasonal fluctuations. Although **most female birds only have a left ovary and uterus**, a **cystic remnant of the right oviduct** can often be found upon close inspection of tissues near the cloaca. The murre at left has a large, active ovary and uterus. **What sex is your bird?**

Left: The ventral surface of the kidney, showing a **small (immature) left ovary and uterus**.
Right: The same view of an **adult female with seasonal atrophy** of the **ovaries and uterus**.
The small yellow/orange adrenal glands are often hidden beneath the gonads, so they can be hard to see.

Looking more cranially in the coelomic cavity, see if you can identify the liver, lungs, heart, trachea, esophagus, and the tiny, but very important thyroid glands. What does the thyroid gland do? There are often two important, but even tinier structures located adjacent to the thyroid glands, the parathyroid gland and the ultimobranchial body. Both can be extremely hard to see grossly, except in very large birds.
Here is a microscopic view of the avian thyroid gland.

Leaving the coelom for a few minutes, let’s examine the ventral mandibular area, where you should see the trachea, a cartilaginous ringed tubular structure. In some species the trachea is very hard and bone-like, (eg. grebes), while in others it is very soft and compressible (eg. loons, pelicans, diving ducks). Keep this in mind when handling these species when alive.
The esophagus is located between the trachea and the spine. Separate the esophagus and trachea from the neck muscles using your fingers rather than cutting. Extend this separation as far as you can cranially.

Cut on either side of the tongue and around the base of the mouth to capture the cranial start of the esophagus. You may need to cut through the hyoid bones.

Examine the tongue and glottis, which is the entrance to the trachea. Is your bird’s glottis large enough to permit accidental passage of a feeding tube or pill down into the trachea? Look at your neighbors’ birds, and see how different species vary.
Using the esophagus and trachea as a handle, continue separating tissue from the neck, all the way down to the ‘thoracic inlet’, where the clavicles help form a bony divider between the neck and coelomic cavity.

Cut along the ventral edge of the **lungs** where they meet the ribs. Lungs should be pink and fluffy-looking when fresh, redder and wetter when previously frozen.
Use the back of a metal scalpel handle or the back end of a forceps to gently pry the lungs from between the ribs by scooping down the channel between ribs. Free the lungs all the way to the spine. This is the best way to thoroughly examine the lungs as it allows you to see the dorsal side, where lesions are often found.

Sever the attachments and blood vessels at the thoracic inlet to allow the esophagus and trachea to continue separating from the spine.
Reflect the esophagus and trachea caudally and gently free the cranial end of the lungs from the ribs.

Use blunt and sharp dissection to free the tissue along the spine. The lungs, heart, liver, GI tract should lift off the spine with your bundle of tissue, leaving an empty rib cage behind.
Use blunt and sharp dissection to free the kidneys from the cavities where they are located on the ventral side of the synsacrum (pelvis).

Continue gently pulling the viscera caudally freeing tissue from the body walls as you go. When you get as caudal as possible, cut through and disconnect the feathered skin around the cloaca without piercing it.
Ta dah! You have removed the bird’s organs from tongue to vent! Now examine all of the organs and see how they relate to adjacent organs. Notice how long the kidneys are in this Western Grebe. How do they compare with your bird’s anatomy? Now you can examine each organ in turn.

The heart: remove it from the lungs and slice through the right ventricle up into the pulmonary artery. Note the muscular flap that forms the valve on the right side. Cut up into the atrium through the valve.
Cut open the left ventricle through the aorta. Note the tricuspid tendinous valve that forms a barrier between the left atrium and ventricle. Cut into the atrium. Notice the semi-lunar vales at the entrance to the aorta.

**Lungs:** Notice the shape of the dorsal side of the lungs, which often hold the shape of the rib cage like a jello mold. Feel the texture; normal avian lungs should feel fluffy and soft without lumps, and should be bright pink-red as shown above
Make several slices through the lungs to look for lesions (eg bread-loafing). This is important because abnormalities can be easy to miss when located inside of solid organs like lung and liver.

Liver: Examine and palpate the liver for lumps and lesions. The edges of liver lobes are sharper on some species and more rounded for others, but excessively sharp or rounded edges are abnormal. Chicks and hens in breeding condition may have a plump tan liver due to fat storage. Emaciated birds may have a tiny atrophied liver. Sick birds may have an enlarged liver, but sick birds that are also emaciated may have any size liver. Frozen-thawed carcasses may show substantial changes in liver color, so beware over-interpreting color in previously frozen birds. Greenish staining of organs around the gall bladder is a common artifact due to post-mortem bile leakage.
Similar to the lungs, slice through the liver (breadloaf) looking for lesions.

Find the **spleen** on the dorsal side of the proventriculus (stomach), typically near the junction of the proventriculus and ventriculus. Examine the spleen for lumps or lesions, and assess size. Compare with other groups to see how the spleen differs in shape between species. Cut it open and notice the texture.
The kidneys are extremely long in some species like grebes and loons. If the bird was euthanized by injection into the medial metatarsal vein, there may be euthanasia artifact of a firm and slightly gritty texture at the cranial end of the kidneys. Slice each kidney open, examine the texture and look for abnormalities.

Examine the syrinx where the heart was removed. This structure is highly modified for sound production in some avian species.
Here is a microscopic view of the syrinx of a smaller bird. The dark purple areas are bands of hyaline cartilage.

Cut into the trachea along its length.
Look for **plaques, food, mucous, or lesions** along the tracheal walls all the way up to the glottis.

**Gl tract:** Do this last due to its smelly and messy nature, and to avoid contamination of the other tissues with digesta! Cut down the esophagus from the cranial end. Look carefully for any surface plaques or other lesions.
A stylized view of the **avian gastrointestinal tract**. The morphology varies markedly by species and diet. Most aquatic birds do not have **crops**, but instead store ingested meals in their expandable esophagus and proventriculus. Many seabirds do not have a large, muscular **ventriculus (gizzard)**, an adaptation for grinding hard foods like grain and seeds, although some diving ducks have a muscular ventriculus to grind up snails and clams. Many seabirds have a soft and thin-walled ventriculus adapted for eating fish.

Note any food or parasites in the GI tract, as well as any hard materials. This Cormorant has numerous **parasitic worms**, as well as **otoliths** in its ventriculus (center right). What are otoliths and why might they be important to save for later examination?
Cut all the way down through the **proventriculus** (the glandular stomach) and **ventriculus** (the mixing/grinding stomach). Some green (bile) staining is normal, but excessive staining could indicate starvation or disease. As shown above, grebes normally maintain a feather ball in their ventriculus.

It is common for birds to ingest small **rocks** to aid with grinding food in their ventriculus. However, this bird has also ingested **plastic**-Can you see it? Note also the parasitic **worms** in the wall of the proventriculus.
A normal feather ball in the ventriculus of a Western Grebe.

The inner, koilin layer of the ventriculus protects the surface during grinding and mixing of food. It is made of proteinacious secreted material, and has a structure that aids in grinding, kind of like sandpaper.
A microscopic view of the avian ventriculus showing the homogenous, pink secreted koilin (left), and the underlying secretory epithelium (right). The broad white line of separation between these two is a tissue processing artifact. **If you are planning to examine the ventriculus microscopically, it is best to collect sections prior to removing the surface koilin.**

Examine the duodenum and pancreas, which lies in the groove between the duodenal loops. The pelican pancreas looks more like that of a mammal (fleshy pinkish-tan lobed structure located near the ventriculus). In a fat pelican the pancreas can be challenging to find! The pale pancreas at right is from an anemic bird.
**Intestines:** cut open a few spots in different areas of the intestines, look at the color and texture of the digesta, look for parasites and other abnormalities.

**Ceca:** Most avian species have paired ceca that are located at the junction between the small and large intestine near the cloaca. Marked variation in cecal size is noted, depending on species and diet. In herbivores they are used for microbial fermentation of plant matter, so birds that eat vegetation often have bigger ceca than carnivorous birds. The ceca can also be important in nitrogen metabolism, and often have important immune function as well, with prominent lymphoid patches.
Here’s a question for the hotshot avian anatomists! What is this short, unilateral, blunt-ended tubelike structure that is projecting off of the small intestine of a younger bird? What is it a remnant of? (For a hint, look at the picture below)
On the dorsal side of the **cloaca**, juvenile birds may show a bulbous organ protruding from the wall. This is the **Bursa of Fabricius**, which is an important part of the avian immune system. It atrophies (gets smaller) as the bird matures. Examine the cloaca for hemorrhages and look at the character of the droppings.

Here’s an example of a large, well-developed **Bursa of Fabricius** in a very young bird. What does this organ do and what is the mammalian equivalent?
Opening the skull: skin the skull.

Find the back of the skull at the first joint with the spinal column (arrow).
Cut laterally across this space to expose the spinal cord within the joint.

This exposes the ‘foramen magnum’, the hole at the back of the skull where the spinal cord connects with the brain.
Using blunt-sharp scissors, cut at an angle through the skull around its perimeter in an arc that ends dorsal to the eyes. Keep the point of the scissors pointed towards bone to avoid tearing the brain.

Continue the cut.
Once the cut is complete, lift the top of the skull gently away from the brain.

Expose the brain and examine it.
Extract the brain from the skull using a gentle touch with a rounded flat blunt object (kind of like scooping pudding out of a container while retaining the shape of the container).

Voila! Cut it off at the spinal cord.
Dorsal brain surface

Ventral brain surface
Other specialized structures to look for

Salt gland

Uropygial gland