Respiratory System of Birds: Anatomy and Physiology

Holly Nash, DVM, MS
Veterinary Services Department, Drs. Foster & Smith, Inc.

Differences between avian and mammalian respiration

Respiration in birds is much different than in mammals.

- Birds have a larynx, but it is not used to make sounds. Instead, an organ termed the "syrinx" serves as the "voice box."

- Birds have lungs, but they also have air sacs. Depending upon the species, the bird has seven or nine air sacs. The air sacs include:
  - Two posterior thoracic
  - Two abdominal
  - Two anterior thoracic
  - Two cervical (these are not present in some species)
  - One interclavicular

- The air sacs of birds extend into the humerus (the bone between the shoulder and elbow), the femur (the thigh bone), the vertebrae and even the skull.

- Birds do not have a diaphragm; instead, air is moved in and out of the respiratory system through pressure changes in the air sacs. Muscles in the chest cause the sternum to be pushed outward. This creates a negative pressure in the air sacs, causing air to enter the respiratory system. Expiration is not passive, but requires certain muscles to contract to increase the pressure on the air sacs and push the air out. Because the sternum must move during respiration, it is essential that it is allowed to
move freely when a bird is being restrained. Holding a bird "too tight" can easily cause the bird to suffocate.

- Because birds have air sacs that reach into the bones, and have no diaphragm, respiratory infections can spread to the abdominal cavity and bones.

- Bird lungs do not expand or contract like the lungs of mammals. In mammalian lungs, the exchange of oxygen and carbon dioxide occurs in microscopic sacs in the lungs, called 'alveoli.' In the avian lung, the gas exchange occurs in the walls of microscopic tubules, called 'air capillaries.'

- The respiratory system of birds is more efficient than that of mammals, transferring more oxygen with each breath. This also means that toxins in the air are also transferred more efficiently. This is one of the reasons why fumes from teflon are toxic to birds, but not to mammals at the same concentration.

- When comparing birds and mammals of similar weight, birds have a slower respiratory rate.

- Respiration in birds requires two respiratory cycles (inspiration, expiration, inspiration, expiration) to move the air through the entire respiratory system. In mammals, only one respiratory cycle is necessary.

### Respiratory cycle of a bird

1. During the first inspiration, the air travels through the nostrils, also called nares, of a bird, which are located at the junction between the top of the upper beak and the head. The fleshy tissue that surrounds them, in some birds, is called the cere. As in mammals, air moves through the nostrils into the nasal cavity. From there it passes through the larynx and into the trachea. Air moves through the trachea to the syrinx, which is located at the point just before the trachea divides in two. It passes through the syrinx and then the air stream is divided in two as the trachea divides. The air does not go directly to the lung, but instead travels to the caudal (posterior) air sacs.
A small amount of air will pass through the caudal air sacs to the lung.

2. During the first expiration, the air is moved from the posterior air sacs through the ventrobronchi and dorsobronchi into the lungs. The bronchi continue to divide into smaller diameter air capillaries. Blood capillaries flow through the air capillaries and this is where the oxygen and carbon dioxide are exchanged.

3. When the bird inspires the second time, the air moves to the cranial air sacs.

4. On the second expiration, the air moves out of the cranial air sacs, through the syrinx into the trachea, through the larynx, and finally through the nasal cavity and out of the nostrils.