

# Aspiration in Juvenile Squirrels: Etiologies, Treatments, Prevention

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**Abstract:** Respiratory problems are, unfortunately, rather common in juvenile squirrels in rehabilitation. Such problems often result from feeding practices, whether by a rescuer, volunteer or even rehabilitator. Diagnostic methods as well as conventional, botanical, and homeopathic treatments are described. Practical and effective tips to prevent aspiration are included.

**Key words:** Squirrel aspiration, squirrel pneumonia, respiratory distress in squirrels, treating aspiration, preventing aspiration, squirrel breathing difficulty, squirrel feeding problems, rodent respiratory problems

## INTRODUCTION

Respiratory problems are, unfortunately, rather common in juvenile squirrels in rehabilitation. Members of the public, veterinary clinic staff, and others often mistakenly conclude the rescued young squirrel is thirsty and hungry and attempt to feed it before contacting a rehabilitator. Although the motives are sincere, the feeding technique often results in some of the liquid inadvertently entering the squirrel's respiratory system. The same thing may occur during feeding by rehabilitators or their volunteers. Animals that aspirate fluid into the lungs, such as water or milk replacement formula, may develop serious respiratory conditions resulting in fatalities. This paper describes aspiration, signs and symptoms, etiologies, methods to prevent it, and several treatments, if needed. It also compares aspiration with several other respiratory conditions in young squirrels.

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## WHAT IS ASPIRATION?

Aspiration refers to the process by which foreign material, such as milk replacement formula, isotonic liquid, water, or small solid particles such as wood dust, enter the respiratory system.

The presence of foreign material in the lungs may cause inflammation and swelling. Additionally, some foreign material in the lungs, such as milk formula, is a fertile medium for bacterial growth and subsequent infection. Larger amounts of foreign material in the lungs pose a greater risk of infection and also provide a growth medium for the bacteria. In some cases, the volume of foreign material in the lungs is so large that the fluid actually prevents the animal from being able to inhale adequate air to breathe. Such severe cases are more accurately described as drowning, even though the respiratory condition was a result of improper feeding rather than being submerged in water.

Juvenile squirrels that have fluid enter the airways and nasal passages also are described as having aspirated. Fluid in the nasal passages may result in inflammation or infections similar to that which occurs in the lungs. If the squirrel had fluid come out of the nose during feeding, there is a fairly high probability that the feeding method caused fluid to enter the lungs, which is more serious.

A squirrel with other health problems, such as dehydration, wounds, and abscesses, may be weaker and more susceptible to quickly developing infections from aspiration than would a healthy animal. An animal whose health is already compromised may be using its resources to recover from other conditions and may have a slower or more difficult recovery from respiratory conditions.

## SIGNS AND SYMPTOMS

Some of the signs of aspiration are obvious. Others are much more subtle, develop gradually, and are difficult to notice. Wild animals naturally attempt to hide health problems so as not to appear vulnerable to predators, which makes it more difficult to detect a developing health problem. The more familiar a rehabilitator is with what is normal, including activity, respiration, sleep, appetite, and growth, the better the chance of noticing the subtle initial clues. The following describes physical signs of aspiration, both at the time of feeding and later, as well as some observational and circumstantial clues that might suggest the animal aspirated during the feeding process, even though the actual aspiration may have gone unnoticed when it occurred.

**During Feeding.** Among the first signs that the squirrel may be aspirating at the time of feeding are obvious sneezing and liquid or bubbles of formula coming from the nostrils. The squirrel may gag or choke, and back away from or fight the syringe, sometimes being mistaken as a ‘fussy eater.’ The squirrel may have difficulty swallowing and/or regurgitate formula from the mouth or through the nose. Regurgitation may be a sign of having too much fluid to safely swallow. Regurgitation and vomiting are particularly difficult for rodents due to the presence of a limiting ridge at the junction of the stomach and esophagus (Hillyer and Quesenberry 2004; Cunliffe–Beamer 1993).

The moment of aspiration should be apparent to the person feeding the young squirrel if obvious sneezing or gagging suddenly occurs. However, *there are many cases where fluid enters the squirrel’s trachea, or airway, without any obvious indication the liquid has moved down into the lungs.* As a result, it is important for the rehabilitator to pay close attention during feeding and watch for and recognize subsequent signs of respiratory problems. Respiratory conditions can deteriorate quickly and should not be taken lightly.

**Reluctance to Eat.** Signs of aspiration may appear immediately, a few hours, a day, or several days later. A squirrel that previously demonstrated a good appetite at regularly scheduled feedings may suddenly refuse food or only swallow a couple of drops of formula instead of eating the expected amount. This may be an indication the squirrel feels ill and/or eating hinders respiration. Given the alternative between eating and breathing, the squirrel instinctively chooses to breathe.

Because there are other reasons that a squirrel may not want to eat, the rehabilitator must consider and evaluate those possibilities as well. For example, a squirrel that refuses formula may not yet be hungry for valid reasons, including the amount of formula it was fed earlier, feeding schedule, or increased consumption of solids. Other health conditions such as stress, side effects of medications, or other conditions could reduce interest in food. Or the formula just could be too hot and burning the squirrel’s mouth. If other squirrels in the same environment, of the same age, and on the same feeding schedule are hungry and eager to eat, the rehabilitator needs to closely consider the reason for the specific animal’s reluctance to eat—which very well could be respiratory distress.

**Activity Level, Sleep, and Chill.** Squirrels that have aspirated tend to be less active than normal and more lethargic. They may sleep more and be difficult to arouse from sleep. They may chill much more easily and quickly, and have difficulty maintaining normal body temperature. A squirrel that feels cool due to aspiration or another health issue, may raise the fur to increase the insulating effect and warmth, and appear to have slightly ‘spiky’ or ‘puffed’ fur. The squirrel may have a slight fever, with their external body temperature appearing warmer than that of the cagemates or siblings. Since taking the temperature of a juvenile squirrel can be difficult and even dangerous for the animal, it is not necessary. Depending on the level or intensity of these signs, the squirrel may be in early or advanced stages of respiratory distress. Regardless, treatment likely will be needed to help recovery.

**Respiration Level and Rate.** Careful and skilled listening to a squirrel’s respiration may reveal slight sounds of respiratory difficulty, but other signs also provide key clues. Early stages may include a barely audible rhythmic ‘clicking’ sound coming from the nose or chest, coinciding with inhaling and exhaling. Normal respiration is relatively silent. Squirrels with more severe and advanced cases of aspiration or pneumonia may have labored, shallow, and difficult breathing, which may be audible to the caregiver, even without use of a stethoscope, or the caregiver might notice a mild vibration or rattle in the chest. The squirrel may breathe through an open mouth rather than through the nose. The respiratory rate may be abnormally rapid or slow. They may be weak

and even collapsed. Coughing is possible, but not common. These signs of severe respiratory distress indicate advanced disease that requires prompt and targeted treatment to reduce further deterioration and possibly death.

**Circumstantial Clues.** In some cases, circumstances may suggest a high probability that the squirrel has aspirated prior to being presented to the rehabilitator. The rescuer may mention having read information online about feeding squirrels and offer to donate feeding implements and/or an open container of formula. These items are direct clues as to the type of feeding instrument used as well as the type of liquid fed to the animal. Rehabilitators already collect information on the animals admitted for rehabilitation, including rescuer's name and contact data, source location of the animal, and reason for rescue (fall, dog or cat attack, etc.). While collecting this information, it is useful to ask if the person has given the animal any food, liquid, or medication. If the answer is yes, it is important to ask what, how much, and type of feeding instrument. This can provide early information about the possibility of the animal having aspirated, such as if the person mentions that the squirrel was "so excited and cute drinking water from the eyedropper that he blew bubbles out his nose."

Although some rescuers may admit to feeding the squirrel during this general data collection, others may be vague or deny it. However, evidence of formula or other liquid matted on the fur on a squirrel's face or muzzle, or 'plugs' of formula in the nostrils are strong evidence the rescuer tried to feed the animal. If there is any indication that the rescuer may have fed the squirrel, the rehabilitator needs to closely monitor it for signs of respiratory difficulty, as well as potential gastrointestinal disorders and other health problems.

Just as respiratory conditions can be present in animals admitted from the public, a veterinary clinic, or rescue organization, there also are instances when squirrels received from another rehabilitator may show early or later stages of respiratory difficulties. This can be for several reasons, including inexperience or lack of training with feeding the species, inexperience with observing and addressing any of the issues mentioned above, or even an overly large caseload that may have prompted a more fast paced feeding practice and less monitoring of individual cases.

## ETIOLOGIES

Although it is possible for juvenile squirrels to aspirate due to other reasons, such as being gavage- or tube-fed, the most common cause of aspiration is the process by which they are hand fed. This includes such considerations as feeding instruments, position of the animal and feeding instrument, and the rate of flow with which the liquid is fed.

**Volume Administered.** Juvenile squirrels in the wild only obtain a very small amount of milk in their mouths at a time when suckling their mother that they swallow and repeat the process.

The mouths and throats of juvenile squirrels are quite small as is evidenced from examination of multiple specimens. A neonate squirrel that weighs less than 20 g has an esophagus that is less than 0.06 in (0.15 cm) in diameter, approximately the diameter of the wire in a paperclip. A squirrel that weighs between 50 and 100 g has an esophagus that may be 0.12 in (0.3 cm) in diameter, or the diameter of a toothpick. A squirrel weighing between 100 and 300 g has an esophagus that may be 0.15 to 0.33 in (0.38–0.84 cm) in diameter, which approximates the interior diameter of a 1-cc syringe.

People feeding young squirrels must always keep in mind that they have very tiny mouths and throats and must be diligent in efforts not to place too much liquid in the mouth at a time. Although some people may be experienced feeding young kittens and puppies, as well as larger wild mammals, they may not appreciate the significantly smaller size of young squirrels' mouths and throats. They can cause squirrels to aspirate easily, especially if the squirrels are difficult to handle and unfamiliar with the feeding implement, such as squirrels that are recently admitted to rehabilitation.

Many implements commonly used to feed liquid to young squirrels express a larger volume of fluid than the animal may safely swallow. For example, a large syringe sold to administer medication to children or even pets, expresses a volume acceptable for these animals with a larger mouth and throat capacity, but that far exceeds what a young squirrel may be able to simultaneously take into its mouth and swallow, while also breathing.

Some rehabilitators have used 6-cc, 12-cc, or larger syringes to feed young squirrels because the diameter of the syringe nozzles are the same as a 1-cc syringe and they believe it is possible to control the syringe plunger enough to limit the amount of fluid

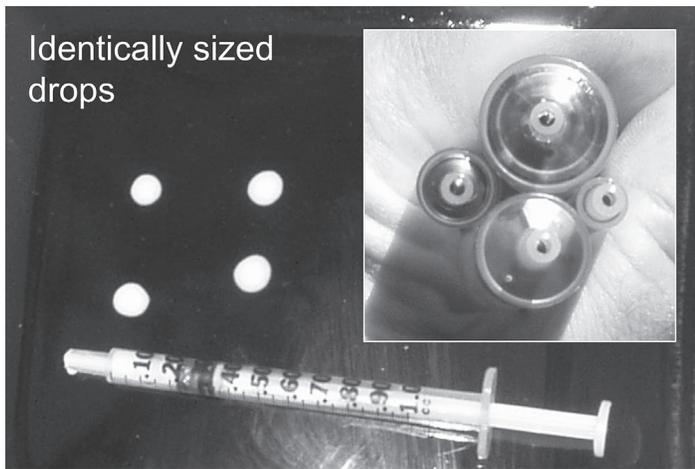


Figure 1. A very focused and skilled rehabilitator may be able expel a single drop of formula from different size syringes. However, aggressive suckling or movement by the squirrel, or a distracted or less skilled caregiver easily may cause more than one drop to be expelled. Photo by Allan Casey.

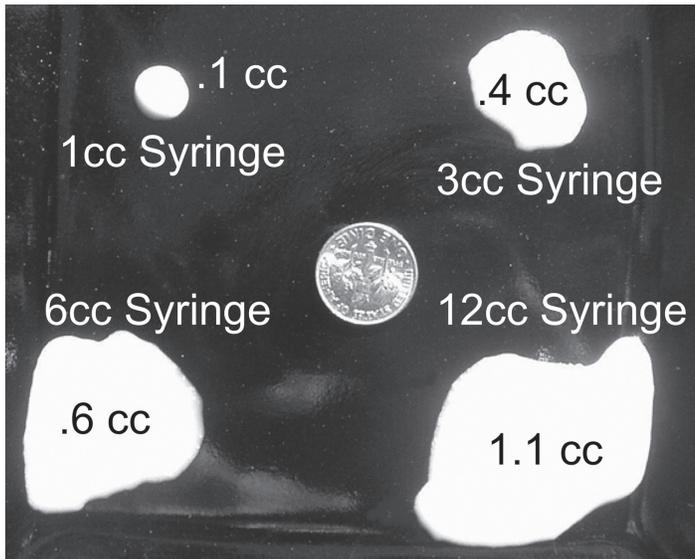


Figure 2. Comparison of the volume of formula expelled by a 0.25 in (0.64 cm) movement of plunger in a 1-, 3-, 6-, and 12-cc syringe. The 0.25 in (0.64 cm) movement of plunger of a 12-cc syringe results in 10 times the volume of the same 0.25 in movement of a 1-cc syringe. The larger volume of formula easily can cause a squirrel to aspirate—without rehabilitator even noticing. Photo by Allan Casey.

going into the squirrel's mouth. It is indeed possible for a person with considerable control on a plunger of a larger syringe, such as a 6-cc syringe, to expel a single drop from the nozzle as shown in Figure 1. However, moving the syringe plunger a small distance, such as a quarter of an inch (0.64 cm), results in a much larger amount being expressed from a 6-cc syringe than the same quarter of an inch from a 1-cc syringe, as shown in Figure 2.

Many rehabilitators find that a small syringe, such as a 1-cc or 3-cc, allows significantly more control over the amount and rate of fluid fed to the squirrel. However, even a 1-cc or 3-cc syringe can cause a young squirrel to aspirate if the plunger moves farther and expels more fluid than the squirrel can comfortably take into its mouth, swallow, and breathe. Also, if the squirrel is extremely small, such as less than 25 g, even a full drop of a formula from a 1-cc syringe, about 0.05 to 0.1 cc, may exceed the capacity of its mouth.

Some rescuers have used eyedroppers and ear bulb syringes to feed squirrels. It is extremely difficult to control the amount of liquid expelled from these devices. These implements as well as larger syringes easily can cause the animal to aspirate, as the rate of flow is too large, fast, and uncontrollable as to volume.

**Speed of Feeding.** Most juvenile squirrels have a healthy appetite and are eager to eat. The rehabilitator, who also may be very busy and eager to complete the task, may respond by feeding quickly. However, feeding liquid quickly may easily exceed the capacity of the young squirrel's mouth and throat. Feeding too rapidly can result in excess liquid coming out the nose or mouth, or aspiration. Like large feeding implements, rapid feeding is a common cause of aspiration in squirrels.

Feeding too quickly can result from a couple of primary factors. The rehabilitator may be rushed and inclined to provide too much volume too quickly. Another factor is not providing adequate control of or 'back-pressure' on the plunger of the syringe. Young squirrels have a strong sucking pressure needed to extract the milk from the mother's nipple, which excretes milk at a very low rate. If the rehabilitator does not exert adequate back-pressure on the syringe plunger, an aggressively hungry squirrel can move a new or well-lubricated syringe plunger much too quickly, resulting in an overload of formula into the mouth, and airways or lungs.

**Length of Feeding Implement.** The teats of lactating female squirrels are 0.06 to 0.33 in (0.15–0.085 cm) in length, depending on species. Smaller species, such as southern flying squirrels (*Glaucomys volans*), pine squirrels (*Tamiasciurus hudsonicus*), or many of the ground squirrels (*Golden mantles*) have



Figure 3. Similarity of size and shape of nipples in wild lactating squirrels; species left to right are Abert's squirrel (*Sciurus aberti*), golden-mantled ground squirrel (*Spermophilus lateralis*), fox squirrel (*Sciurus niger*). Photos by Shirley and Allan Casey.

shorter and smaller teats than the larger tree squirrels such as fox squirrels (*Sciurus niger*), eastern gray squirrels (*Sciurus carolinensis*), and Abert's squirrels (*Sciurus aberti*). Figure 3 demonstrates the size and shape of nipples of lactating squirrels in the wild.

Many rehabilitators attach softer nipples to small plastic feeding syringes with the goal of making them more comfortable or natural for the squirrel's mouth. Many of these nipples are longer than 0.5 in (1.27 cm), thus exceed the length of the mother squirrel's teat. A nipple that is allowed too far in the back of a young squirrel's mouth easily can result in 'overflow' going down the trachea. Nipples that extend too far into the throat due to placement or the squirrel's enthusiastic suckling also may impede the swallowing response, again causing fluid to enter the trachea. Such aspiration may be unnoticed by the person feeding. Squirrels also can swallow or inhale the nipple itself causing an obstruction. Even if the rehabilitator tries to keep the nipple at the front of the squirrel's mouth, it can move farther back into the squirrel's mouth or throat because of the squirrel's suckling or because the rehabilitator is distracted and allows movement.

Even without a supplemental nipple, some syringes have nozzles exceeding the 0.5 in length. Again, while the rehabilitator may try to keep the tip in the front of the squirrel's mouth, it is not unusual for a hungry squirrel to suck or pull the nozzle into the back of the mouth and aspirate.

### Feeding Position.

Rehabilitator observations as well as video cameras of wild squirrel mothers in nests reveal that the mothers generally recline on their sides or even more on their back when feeding their young. Neonate squirrels lean against the mother in a more upright or vertical position when they suckle (Figure 4). Older and larger juvenile squirrels lie more on the stomach with the upper bodies and head angled toward the mother's teats. They use the front feet to hold, push, or 'knead' the mother's mammary glands as they suckle.

Squirrels that are not held in positions similar to the way they would suckle the mothers may be uncomfortable and stressed and have difficulty swallowing appropriately. Squirrels fed lying on the back may aspirate easily. If the squirrel's head is tipped too far to the back, front, or side, the position may cause difficulty swallowing. Squirrels that are not provided with a secure surface under the body may be more stressed and squirm more during feeding, which can result in them aspirating. While infant squirrels may be held in a more vertical position, older squirrels with fur should not be held in the air or perched on an unstable surface while feeding. Stressors and other



Figure 4. Neonate fox squirrel (*Sciurus niger*) suckling its mother. Photo by Sharon Baird.

distractions that cause the squirrel to be agitated or move also may result in gulping or inappropriate swallowing.

The position of the rehabilitator during feeding may affect the squirrel's position and ability to effectively swallow. For example, a rehabilitator that holds the syringe high may cause the squirrel to have difficulty swallowing because the head is too high. Holding the syringe in an uncomfortable position may reduce the rehabilitator's control on the syringe, allowing the squirrel to suckle too much at a time and aspirate. A squirrel that is held too close to the rehabilitator's body, especially the face, may try to escape what they consider to be a predator, resulting in risky swallowing.

**Animal Adjustment to Implement and Formula.** Even with attempts by rehabilitators to create a comfortable and effective feeding implement, the instruments are different from the mother squirrel's teats. As a result, juvenile squirrels have to adjust to the feeding implement, how liquid is disbursed, and the density or viscosity of the liquid. The squirrel may exert the same type of forceful suckling that they do with the mother, even though strong suckling is not needed as the rehabilitator releases liquid from the syringe.

Additionally, newly admitted squirrels are accustomed to swallowing the thicker mother's milk. As a result, the squirrel may get too much replacement formula too fast, swallow 'wrong,' and aspirate some of the liquid. This is especially a concern for animals that are new to rehabilitation being fed a rehydration liquid, such as lactated Ringers solution or dilute formula, both of which, by design, have more water content than full strength milk replacement formula.

**Sticking Plunger.** The seal on the plunger of some syringes has a tendency to stick or move unpredictably after being used many times. This can cause the rehabilitator to use extra pressure to move the plunger. The plunger then may move farther and faster than expected, resulting in a gush or sudden abundant flow of formula that may exceed the squirrel's ability to swallow. This sudden rush of formula can cause the squirrel to gag, choke, blow bubbles from the nose, or aspirate formula into the lungs.

**Distractions.** Rehabilitators and volunteers have many responsibilities and activities. They are busy. As much as they try to focus on feeding carefully, it is

possible a rehabilitator's attention may be distracted for a couple of seconds, such as hearing a phone ring, being asked a question, noticing a problem with another animal in rehabilitation, and so forth. In that momentary distraction, it is possible that the rehabilitator pushes the plunger too far and causes the squirrel to take in too much formula, or they forget to maintain adequate back-pressure on the syringe plunger. The same type of accident may happen if the rehabilitator is hurrying due to a hectic schedule and heavy workload. Exhaustion due to workload, long hours, loss of sleep, and other stressors can result in aspiration, as well as other problems, including overfeeding, missed medications, and injuries.

**Cumulative Effects.** Any one of the situations mentioned above can cause a squirrel to aspirate a lot or a little. The aspiration may be more severe, faster, and more difficult to correct if multiple factors are combined. For example, a large volume of formula may be aspirated if the person is feeding with large syringe with a long nipple that extends to the back of the squirrel's throat. It could be worse if the syringe plunger stuck and then moved farther and faster, resulting in a large gush of formula that entered the trachea and lungs.

A relatively new rehabilitator or volunteer may be feeding a fairly healthy 50 g orphaned squirrel that is newly admitted with a large syringe. The juvenile squirrel may aspirate simply because of unfamiliarity with the feeding method, different density of the liquid, or a syringe that is too large. Add a distraction, like spilling the jar containing the formula, and a gush caused aspiration occurs. Then consider the same situation but with a dehydrated 100 g squirrel with a bruised chest, or a 20 g neonate. If the squirrel aspirated several times, it could cause the fluid to accumulate in the lungs, decrease respiratory capacity, and provide a fertile medium for bacterial growth. If the aspiration is not noticed immediately, such as by a rescuer, new rehabilitator, volunteer, or a very tired and over-worked rehabilitator, the condition may worsen.

Any of these situations and others can cause a young squirrel to aspirate. But if multiple things happen and/or are not noticed until the animal's condition has deteriorated, the animal is much more difficult to treat and survival is less certain.

## **DIFFERENTIAL DIAGNOSES**

Aspiration itself is not a disease, but a physical action. However, it can cause disease very easily and rapidly. Aspiration pneumonia is the most common sequela (consequence). The signs to look for have been discussed above. All of the below conditions require veterinary consultation.

Aspiration pneumonia usually affects the cranial ventral lung fields, the lower front area of the animal's chest. Viral pneumonia, on the other hand, causes congestion and inflammation in all lung fields. Spread of bacteria, from infected wounds or infections in other parts of the body, to the lungs through the blood (hematogenous) also causes congestion and inflammation in all lung fields.

Careful auscultation (listening with a stethoscope) can distinguish the types of pneumonia. Quiet breath sounds are audible in all fields of healthy lungs. Consolidation or congestion causes the absence of normal lung sounds. What often is heard is a smacking sound as the inflamed thickened alveolar membrane opens to admit air on inspiration (inhalation). If these sounds are heard under the front legs, aspiration pneumonia is likely present. Patients with pneumonia very rarely have nasal discharge.

Upper respiratory infections also are possible sequelae of aspiration. The part of the upper respiratory tract affected depends how far into the lungs the foreign substance was aspirated. If the fluid went up the nose then rhinitis (inflammation of nasal passages) or sinusitis (inflammation of the sinuses) is evident. If fluid went into the trachea or bronchi then tracheitis (inflammation of the trachea) or bronchitis (inflammation of the bronchi) is evident. Very harsh, raspy upper respiratory noises are audible when listening to the lungs. Bloody or purulent (pus-filled) nasal discharge is present through coughing, sneezing, or both.

Drowning, on the other hand, is very often accompanied by copious amounts of nasal discharge the same color as the substance that was aspirated, severe dyspnea (difficulty breathing), cyanosis (blue color to the mucous membranes), and complete absence of any lung sounds at all. Drowning is a medical emergency and requires the rehabilitator to remove as much fluid from the lungs as quickly and safely as possible. If the animal has a large amount of fluid in the lungs, consider turning the animal upside down, pressing gently on the chest, and allowing the fluid to flow out of the respiratory tract.

A bulb syringe marketed for use with infant children might be helpful to gently remove fluid from the mouth and throat.

Pneumonia may be the result of conditions other than aspiration. For example, pneumonia may be viral or bacterial from a penetrating chest wound, or a broken rib, or due to spread of infection from other parts of the body.

Difficult respiration also may be due to chest trauma, including hemorrhage or air in the pleural space (space in the chest outside the lungs), bruising of the lungs, or fractured ribs.

Fractured sinuses or other head trauma can be a reason for nasal infection or discharge, instead of aspirated fluid in the nasal cavities.

## **TREATMENT CONSIDERATIONS**

In order to understand treatment options for aspiration cases, it is important to understand the nature of the condition and other influences. How severe was the aspiration? Amount aspirated? Is the fluid in the nasal passages or sinuses? Is it in the lungs? Both?

A tiny amount of formula in the nose of an older juvenile squirrel might be sneezed out quickly and easily. Another option is to gently tip the squirrel forward and encourage the drop to come out. Some rehabilitators have prompted squirrels to sneeze by gently blowing toward the squirrel's nose.

A tiny drop in the nose of an infant squirrel may be removed by placing an eyedropper or human infant nasal aspirator over the nostril and gently extracting the drop. Whereas a large gush of fluid that went into the lungs is unlikely to be removed easily, and has to be absorbed by the body. A larger volume of liquid in the lungs would increase the amount of inflammation.

Also consider the squirrel's condition, overall health, and symptoms. Is the animal showing sign of respiratory distress? Did the aspiration just occur? Have several days passed? Is there a concern that the squirrel is in serious condition? Is there a concern that the squirrel might have just aspirated and the rehabilitator wants to prevent infection from developing?

## Supportive Care.

### Do:

- Feed very carefully to avoid further aspiration.
- Provide supplemental heat for the compromised animal.
- Reduce activity level. Place in a smaller cage either alone or with fewer cagemates so there is less play and activity.
- Provide extra hydration. Depending on the severity of the respiratory condition, administering isotonic fluids subcutaneously may be preferable to oral fluids.
- Ensure excellent nutrition.
- Use a vaporizer or humidifier with warm or room temperature water to make breathing easier and more comfortable. This moisture also helps with hydration and allows easier expectoration of discharge.

### Do not:

- Squeeze the animal's chest.
- Shake the animal upside down to try to 'shake out the liquid.'
- Apply salves with strong odors that are sold for use with people, such as Vicks® VapoRub® (Proctor & Gamble, Cincinnati, OH), that could irritate the skin and nasal passages, as well as cause severe stress due to squirrels' highly sensitive sense of smell.
- Attempt artificial respiration, which could push the fluid further into the lungs.
- Allow the animal to become dehydrated.
- Stop feeding the animal. Rather, take care to feed very carefully and slowly using a 1-cc syringe with a short nipple so the animal gets adequate nutrition but does not aspirate again.

**Conventional Medication.** Antibiotics used in squirrels with confirmed pneumonia or upper respiratory infections include those with targeted effectiveness against bacteria present in the lungs and airways, such as enrofloxacin (Baytril®, Bayer Animal Health, Montville, NJ) for *Pasteurella* and *E. coli* spp., penicillin for *Staphylococcus* and *Streptococcus* spp. and chloramphenicol for a multitude of organisms. However, penicillin related drugs such as amoxicillin and amoxicillin trihydrate/clavulanate potassium (Clavamox®, Pfizer animal Health, New York, NY) are not recommended for rodents, including squirrels, because the drugs can cause a variety of problems, such as hemorrhagic gastroenteritis (bleed-

ing from the intestinal tract). The limited antibiotic choice in rodents can make some infections difficult to treat (Hillyer and Quesenberry 2004; Harkness and Wagner 1989; Cunliffe-Beamer 1993).

Rehabilitators are encouraged to consult with their veterinarians prior to initiating treatment with antibiotics. Antibiotics should be targeted to the specific bacteria present. Without testing through an actual culture, history and symptoms are essential to make an educated guess as to the type of bacteria involved. The correct dose and proper length of treatment are critical for success. Antibiotic treatment for confirmed pneumonia is considerably longer, possibly over four weeks, than treatment for an upper respiratory infection. When using antibiotics, it is vital to administer a probiotic twice daily to reduce the risk of disruption of gut flora and development of diarrhea.

Expectorants generally are not well tolerated or useful in rodents. Some veterinarians have administered Lasix® (furosemide, Sanofi-Adventis US, Bridgewater, NJ) in severe cases of pneumonia to reduce the amount of fluid in the lungs. While oxygen is very important in animals with severely compromised lungs, oxygen chambers are not commonly available at rehabilitation facilities. A squirrel that cannot breathe without supplemental oxygen is likely to have a poor prognosis for recovery due to chronic lung scarring.

**Botanical Medication.** There are many plants that have been used to treat respiratory problems for thousands of years. Some strengthen the overall immune system and the body's general ability to recover from respiratory infection, such as echinacea. Some reduce respiratory inflammation; others are expectorants that help the body to get rid of mucous or excess fluid, such as by coughing or sneezing. These treatments may be highly effective.

Some veterinarians suggest starting with echinacea to strengthen the immune response and for upper respiratory infections. On the basis of research with human patients and traditional preparations, the hydroethanolic liquid extracts may be preferred (Wynn 2007). Many herbalists prefer to give echinacea three times a day and repeat at up to two to four hours in acute stages. While echinacea is available in both dried and liquid forms, the liquids are easier to administer to a squirrel. Other herbs may be added to or used with the echinacea to address more symptoms. Dosages of herbs vary depending on purity,

quality, and strength of the product, condition of the animal, size of animal, and more, The book *Veterinary Herbal Medicine* (Wynn 2007) lists dosages for a variety of herbs.

Other veterinarians may select Chinese herbal medicines. While some of these botanical medicines may be available over-the-counter without a prescription, consultation with a veterinarian is important to ensure effective results and to prevent problems.

### Homeopathic Medication.

Veterinarians using classical homeopathy recommend oral administration of a total of one or two doses of homeopathic *Phosphorus* 30c in the acute and early stages of respiratory distress due to aspiration (e.g., in the first 48 hours of respiratory problems) (Casey and Black 2002; Casey and Herman 2004). Later stages of respiratory distress due to aspiration may involve other homeopathic remedies, such as one or two total doses of *Sulphur* 30c or *Carbo vegetabilis* 30c, according to homeopathic principles. The homeopathic remedies in 30c potencies that are mentioned above are available from homeopathic veterinarians, online sources, or pharmacies.

## PREVENTING ASPIRATION

**Appropriate Feeding Implements.** Small syringes, 1-cc and 3-cc, can be used to effectively and safely feed formula to suckling squirrels as they allow the rehabilitator to have good control over the flow of liquid. These syringes are easy to clean and disinfect, accurately disperse amounts of formula calculated for the size of the animal, and are easily available for purchase and inexpensive.

Many rehabilitators find the O-ring syringe with slip tip to be very effective. The nozzle length is about 0.33 in long (0.84 cm) and the diameter is 0.03 in (0.08 cm). Supplemental nipples fit well on the standard slip tip nozzle, while the O-ring oral slip tip (used for human dosing) is wider and too large for the mouth of younger and/or smaller squirrels. The O-ring plunger slides easily in the barrel and the syringes can be washed, disinfected, and reused thousands of times without the plunger sticking in

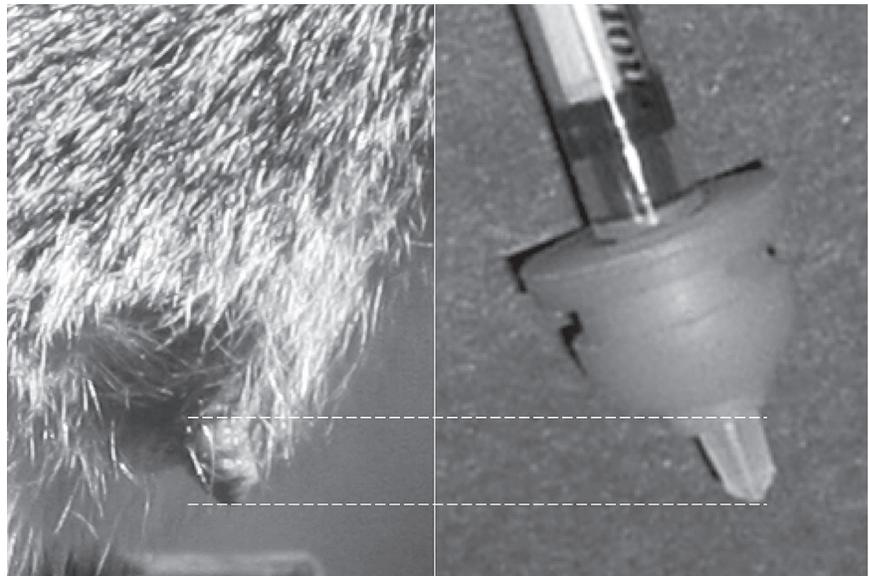


Figure 5. Comparison of a modified squirrel nipple with a lactating female squirrel teat shape and size. Photos by Allan Casey.

the barrel. While the individual O-ring syringes are slightly more expensive than some others, ultimately they are less expensive due to the ability of using them for so many feedings.

The Monoject™ (Kendall Brands, Division of Covidien, Mansfield, MA) with Luer tip is another option used by rehabilitators. The syringe nozzle length and diameter are the same as the O-ring syringe and nipples fit the same. The Monoject™ syringe is designed to have a needle attached to be used for injections, therefore only intended for a single use. While an individual syringe is less expensive than the O-ring syringe, the black rubber seal on the plunger tends to stick after multiple uses and cleanings. The 3-cc Monoject™ syringes are available from many veterinary supply distributors; 1-cc syringes are not available from veterinary supply distributors, but are available from veterinary offices or pharmacies and may require a prescription for purchase.

Use a 1-cc syringe when orally administering water, lactated Ringer's solution, or similar fluids, or when feeding a newly admitted squirrel.

Do not use a bulb syringe or eyedropper for feeding because they are difficult to control and easily cause aspiration.

**Short Nipple.** Placing a small plastic or silicone nipple (Mothering Kit silicone nipple, Classic Products®, Elwood, IN) on the tip of a syringe can help control formula flow and effectively soften the feeding instrument that is placed into the young



Figure 6. A modified feeding nipple using silicone nipple and base of Zoologic® Elongated Nipple with long tip removed and positioned on a 1-cc syringe (left and center). Syringe on right (3-cc) shows modification and placement of the Zoologic® Elongated Nipple for an older squirrel. Photos by Allan Casey.

squirrel's mouth. Use a soft nipple that is the approximate size and shape of the lactating squirrel's teat (Figure 6). The modified feeding nipple shown has been the most effective and most similar to the mother squirrel and allows the young squirrel to grip or push the base as it would the mother when suckling.

The modified nipple is made from placing 0.5 in of the tip of the white silicone nipple on a 1-cc syringe (O-ring or Monoject™ with slip tip Luer nozzle). The silicon nipple tip is pushed through the opening in the base of the Zoologic® elongated nipple that has the tip removed (Figure 6).

When an infant squirrel takes the nipple tip into its mouth, the base of the elongated nipple stops them from sucking the nipple in too far and risking aspiration. The squirrel can hold or pump the wider base easily. It is also easy to draw formula through the nipple into the syringe as well as to clean after feedings. For squirrels with fully erupted teeth (the eyes also are open), consider putting the syringe nozzle through the bulbous base of the nipple so the squirrel has a place to put its paws when feeding. For example, remove the narrow part of the Zoologic® elongated nipple and place the nozzle of the 3-cc syringe through that opening (Figure 6). Avoid using a soft nipple with squirrels with fully erupted teeth because they can bite off and swallow the nipple tip causing a gastric foreign body or inhale it causing a respiratory obstruction.

**Feeding Position.** As mentioned above, the feeding position of unfurred infant squirrels is different from older squirrels that do have fur. Infant squirrels are wrapped in a small piece of soft cloth and held more vertically for feeding, similar to the position they use

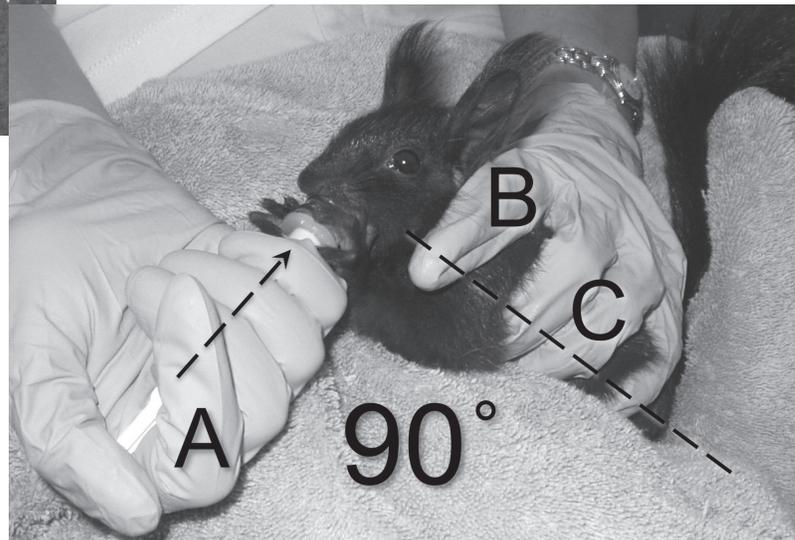


Figure 7. A juvenile Abert's squirrel (*Scurius aberti*) held in a sternally recumbent position on towel and fed with syringe at 90° angle. Line A indicates rehabilitator's fingers curled over syringe plunger to control amount of formula expressed. Left thumb and forefinger (B) form 'U-shaped collar' to maintain squirrel in position. Middle and ring fingers (C) curve under the body to stabilize position and reduce chance of escape. Photo by Allan Casey.

when suckling the mother.

A juvenile squirrel with fur is fed more horizontally in a sternally recumbent position. Feed the squirrel on a stable surface, such as a countertop or a table with a rolled towel, or even a person's lap with a towel.

Allow the squirrel to assume a natural, comfortable, and secure position. The squirrel should be leaning forward on a stable surface, and angled slightly upward, similar to the position when suckling the mother. Some rehabilitators use a towel rolled into a shape like the mother squirrel's torso to be helpful support and give the squirrel a surface to 'knead.' The syringe should be at approximately a 90° angle to the squirrel's head, as shown in Figure 7.

Hold the squirrel securely in that position with your fingers resting on the collarbone in a 'U-shaped' collar shown in Figure 8. Do not place the fingers in front of the throat or mouth. Allow only the tip of the nipple or syringe nozzle into the squirrel's mouth, since that is the approximate length of the mother squirrel's nipple. Preventing the squirrel from taking a syringe nozzle or nipple more than one-third inch into its mouth reduces risk of aspiration.

Keep a finger on the syringe plunger stem (Figure 7) in order to maintain better control over the amount administered. This helps prevent a squirrel that is vigorously sucking from getting too much at a time. Avoid holding the syringe as if giving an injection since that does not allow as much plunger control.

Directing the nozzle of the syringe slightly toward the squirrel's inner cheek is another way to reduce the amount of suction pressure, especially for older juvenile squirrels that tend to suckle quite vigorously (Figure 9). This would be like a person sucking on a straw directed into the inner cheek instead of the center of the tongue.

**Feed Slowly.** Feed slowly, a little at a time. Allow the squirrel adequate time to take the formula into the mouth and swallow before giving more. Do not rush the feeding. Feed using a slow



Figure 8. Overhead view of rehabilitator's fingers in 'U-shaped collar' to hold young pine squirrel's head steady during feeding. Photo by Allan Casey.



Figure 9. Angling a short syringe tip without nipple in fox squirrel's cheek to reduce excessive suckling pressure. Photo by Allan Casey.



Figure 10. Fabric positioned over squirrel's head during feeding to reduce distractions; muzzle, mouth, and front feet must be visible to rehabilitator to feed safely and effectively. Photo by Allan Casey.

and intermittent 'push-pause, push-pause' pattern when feeding with a syringe. The 'push' provides a drop of liquid; the 'pause' allows time to swallow and breathe. It is the difference between one person giving another a sip of water, allowing time to swallow, breathe, and then giving another sip, rather than steadily pouring water down the person's throat. Watch the squirrel's natural feeding rhythm and don't allow animals that try to rush the feeding to do so.

The rate of the push-pause is much slower when feeding smaller and younger squirrels, those that are new to rehabilitation and adjusting to the feeding method, and with liquids that are thinner than full strength formula.

**Reduce Distractions.** This means feeding the squirrel in a quiet room that does not have many other activities that could distract the caregiver or the squirrel. It means focusing on the feeding and not using the time to catch up with phone calls, socialize with volunteers, or other activities.

Minimizing the activities and distractions helps reduce the animal's stress and increases its ability to focus on eating. In some cases, wrapping much of the squirrel's body in a soft cloth, such as a knit tee shirt fabric or small hand towel, can help reduce visibility of distractions, give the squirrel a secure surface to grab, and also help reduce risk of an older juvenile squirrel getting loose in the rehabilitation facility (Figure 10).

**Training and Supervision.** If a volunteer or new rehabilitator is helping with feeding, training and demonstrations on general rehabilitation practices and feeding techniques are essential. Explain potential problems, how to avoid them, and what to do if they occur, such as aspiration and escapes in the rehabilitation facility. Have the new person learn by feeding some 'easy to feed juvenile squirrels' that are familiar with eating from the syringe while the rehabilitator observes, coaches, and assists over multiple feeding sessions.

As skill increases, continue the person's training with squirrels of different ages, sizes, and health conditions. Do not assume that a single feeding session or working with just one or two squirrels means the trainee has skills for all squirrels. Continue regular monitoring and coaching to help ensure the person provides quality care and to reduce the risk of problems.

When a rescuer calls about a young squirrel, explain the importance of getting it to a rehabilitator. Also explain that as much as he or she may want to feed it, a baby squirrel very easily can inhale the liquid and develop fatal pneumonia, even if the rescuer has experience feeding pets.

**Have a Plan.** Understand aspiration, causes, and ways to prevent it, as described in this paper. Ensure that others, such as volunteers, helping to feed juvenile squirrels are trained and skilled in effective feeding methods and how to prevent problems. Be alert to signs of aspiration. If aspiration is suspected or there are strong signs that the animal is developing respiratory problems, monitor closely, consult with a veterinarian, and initiate treatment as needed.

As always, a positive working relationship with a veterinarian is essential, and should be established before a crisis occurs.

### **PREVENTING ASPIRATION IS BETTER THAN TREATING IT!**

Aspiration that occurs during rehabilitation is a preventable situation. Specialized syringes and nipples described above can make a difference, as well as using an appropriate feeding position, feeding slowly with a push-pause pattern, reducing distractions, and ensuring those responsible understand and use effective feeding practices.

### **PRODUCT RESOURCE**

O-ring feeding syringes and silicone nipple products are available from <[www.Squirrelsandmore.com](http://www.Squirrelsandmore.com)>.

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