# Wound Management Considerations for a Canada Goose *(Branta canadensis)* following an American Alligator *(Alligator mississippiensis)* Attack

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## Introduction

A four month old intact female Canada goose (*Branta canadensis*) presented to the Wildlife Hospital of Louisiana at the Louisiana State University School of Veterinary Medicine following an attack by an American alligator (*Alligator mississippiensis*). The attack had occurred two hours prior to presentation. On physical exam, the bird was bright, alert, responsive, and had clear heart and lung sounds. All systems besides the integument were within normal limits upon initial presentation. The bird (3.0 kg) was in good body condition (2.5/5).

The bite wounds were extensive. Peri–cloacal tissues (e.g., skin, muscle, connective tissue) were macerated. The authors' were concerned that the cloaca might have diminished function or be non–functional since the pericloacal tissue was severed almost 360 degrees, with the cloaca connected to the body wall by minimal tissue attachments. Because of the extent of the injury, it was difficult to characterize which tissues remained. The pygostyle, or the fused caudal coccygeal vertebrae, was exposed, with extensive loss of surrounding soft tissues (Girling 2003) (Figure 1).

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Because of the extensive nature of the injury, the authors were unsure if the skin could be closed over the wound. A small puncture wound was noted in the right side of the abdominal air sac. The uropygial gland had been removed during the attack. The uropygial gland is an important structure in waterfowl, and is used to keep the beak, feathers, and scales supple, insulated, and waterproof. The uropygial gland also prevents the growth of microorganisms and is the principle cutaneous gland of birds. The gland secretes a holocrine lipid (Girling 2003). The loss of the uropygial gland in waterfowl can be catastrophic, as the animal would not be able to float or swim when released.

## Materials and Methods

After physical examination, a problem list was developed. The primary problems addressed in this case included: a degloving skin injury over the caudal spine and tail, contaminated tissues resulting from exposure to the oral microflora of the alligator, exposure of the pygostyle, damage to the peri–cloacal tissues, loss of the uropygial gland, puncture to the abdominal air sac, blood and fluid loss as a result of the attack, and loss of the skin. Based on the problem list, the authors considered the prognosis for the case to be guarded for life and grave for release. Each problem needed to be addressed to ensure success.

Initial diagnostic tests included a complete blood count (CBC), plasma biochemistry panel, microbiological culture of exposed tissues, and pelvic radiographs. The CBC and plasma biochemistries were unremarkable. However, this was not unexpected, as the injury had only occurred hours earlier.

There was no growth from the aerobic culture after 48 hours; however, because of the extent of the injury, opportunistic infection remained a concern. Negative bacterial cultures can occur for a variety of

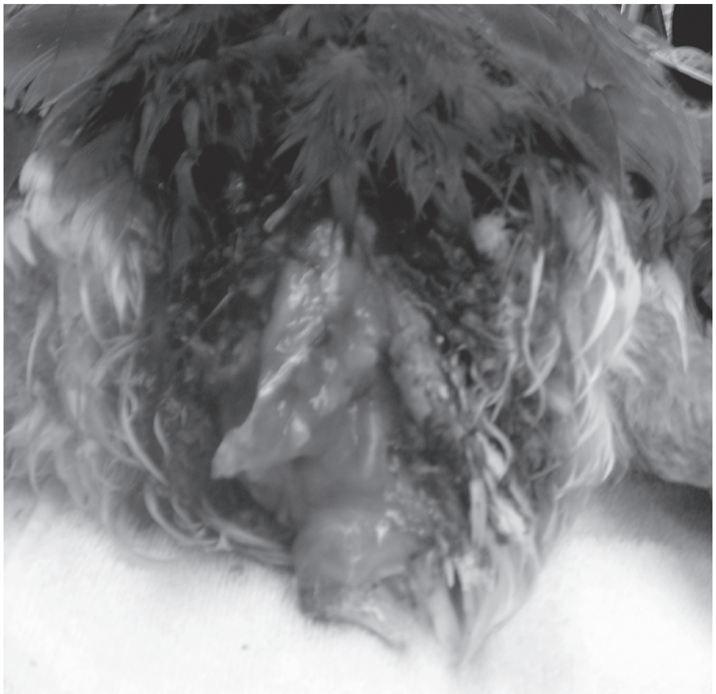

*Figure 1. Initial presentation after attack showing the exposed pygostyle and partial detachment of the cloaca.*

reasons, including the methods used to transport and isolate the microbe. The sensitivity of culture is considered moderate (60–80%), and is subject to false negatives. Since the culture was negative, the authors relied on the literature to guide the treatment plan. The oral microflora of an alligator should be considered mixed, including both Gram–negative and Gram–positive bacteria. One of the organisms routinely isolated from the oral cavity of alligators is *Aeromonas hydrophila*. Gordon et al (1979) isolated *A. hydrophila* from the oral cavity of 85 percent of the captive and wild alligators they sampled. This bacterium is a Gram–negative aerobic rod widely distributed in fresh water and sewage. In humans, *A. hydrophila* has been associated with severe cellulitis, wound infection, acute diarrhea, and septicemia (Novak and Seigel 1986). Because of the ubiquitous nature of this organism in aquatic systems, alligator oral cavities, and its potential for causing disease, this organism was considered a potential contaminant of the wound. In cases where an organism cannot be isolated, and there is a significant loss of the integument (e.g., innate immune protection), broad spectrum antibiotics should be considered. In this case, enrofloxacin (15 mg/kg per os, twice daily) and metronidazole (50 mg/kg per os, once daily) were given in combination to provide broad–spectrum aerobe (enrofloxacin) and anaerobe (metronidazole) protection. A single study in Nile crocodiles (*Crocodylus nilotics*) found that *A. hydrophila* was susceptible to enrofloxacin (Turutoglu et al 2005). It is important to recognize that this type of information can be used to guide treatment, but should not be considered in absolute terms, as similar species of microbes can develop resistance to antibiotics based on environmental pressures.

The provision of analgesics was considered important in this case because of the extensive nature of the injury. Managing pain in avian species can be difficult, as understanding of pain in these animals is limited (Paul–Murphy and Ludders 2001). In most cases, assessing pain is relegated to monitoring behavior, appetite, and mentation. This particular bird remained bright, alert, and responsive, and continued to eat and drink. Although the animal appeared unaffected, it is important to recognize that many animal species have evolved to mask illness as a natural defense mechanism; this would not be unexpected in waterfowl. Thus the determination was made that analgesics would be important. Meloxicam (0.5 mg/kg per os, once a day) and butorphanol (0.5 mg/kg intramuscularly, twice daily) were given to reduce inflammation and provide analgesia (Plumb 2005). Opiods have been found to produce analgesia in avian species, but the results have been variable among species. Meloxicam is a non–steroidal anti–inflammatory (NSAID) and therefore offers another method and pathway to block pain (Paul–Murphy and Ludders 2001).

The integument plays an important role in preventing fluid loss. Because of the extensive nature of the injury in this bird, fluid therapy would be important. Although the animal was not clinically dehydrated, and hematologic data did not indicate significant fluid loss, Normosol® fluids (HOSPIRA, Lake Forest, IL) (100 ml/kg/day) were given intravenously (medial metatarsal vein) initially at a rate of twice maintenance and then tapered to maintenance over the course of several days to account for losses not previously accounted after the injury. Maintenance fluids (per os) were continued during the treatment period until the wound was repaired.

Radiographs were taken to evaluate the pelvis for fractures, and the extent of soft tissue injuries associated with the attack. The bird was anesthetized for the radiographs using isoflurane (Abbott Laboratories, Abbott Park, IL). The bird was masked down with 5 percent isoflurane (1 L oxygen/minute) until anesthetized, and then intubated using a 4.0 (outside diameter) endotracheal tube. The bird was maintained on 2 percent (1 L oxygen/minute) isoflurane during the procedure. The pelvic radiographs were unremarkable.

While the animal was anesthetized, assessment and treatment of the wound was done. The wound was first lavaged with 0.9 percent saline and 0.05 percent chlorhexidine (Ft. Dodge Animal Health, Ft. Dodge, IA) to remove any contaminants and dried blood. The pygostle was amputated via disarticulation to a level that would allow eventual skin coverage. The tissues removed were considered necrotic. The cloaca was sutured (4–0 polydioxanone PDS II™; Ethicon, Somerville, NJ) into place using simple interrupted tacking sutures. Care was taken to avoid penetrating the abdominal air sac. Once the cloaca was repositioned, tension sutures were used to draw skin margins closer together for eventual granulation. Polydioxanone suture was used for this case because it appears to stimulate the least amount of tissue reactivity in birds (Bennett et al 1997).

The wound was managed using a multistage process. First, the wound was debrided (Figure 2). Removal of necrotic tissue is essential to wound healing. After debridement, the wound was irrigated with a 50 percent sterile dextrose solution. The dextrose remained in contact with the wound for 30 seconds. After the 30–second contact period, the dextrose was removed by irrigation with 0.9 percent sterile saline. This dextrose–saline procedure was repeated three times. Chlorhexidine (0.05%) was also used for disinfection. A wet–to–dry bandage was applied to the wound post–debridement (Figure 3). The bandage was comprised of five 4” x 4” (10.2 x 10.2 cm) gauze pads that were moistened with 0.9 percent sterile saline (placed on wound) and five gauze pads that were dry (placed on top of the moistened gauze pads). The gauze pads were held in place by Vetrap™ (3M Corporation, St. Paul, MN). After the wound was considered dry (seven days), the wet–to–dry bandage was discontinued and a semi–occlusive bandage placed. Silver sulfadiazine (Silvadene Crème®, Boots Pharmaceuticals Inc., Lincolnshire, IL) was placed on the wound to provide antimicrobial effects and protect from dessication. Preparation H® (Whitehall–Robins Healthcare, Madison, NJ) was also applied to the pericloacal tissues to reduce inflammation (Riggs and Tully 2004). Anesthesia and debridement were initially done every day; after a couple weeks treatments were done every two to three days depending on wound condition.

*Figure 2. Preparing the bird for wound debridement and cloacal reconstruction.*

Wounds can be allowed to heal by either primary or secondary intention healing. In this bird, the extent of the lesions necessitated the wound be allowed to heal either by secondary intention healing (e.g., tissue granulation) or delayed primary intention healing. For this case, delayed primary closure was performed using a bootlace suture technique (wound closure by suture tightening). Studies investigating the effects of delayed skin closure and bacterial wound contamination on the healing of abdominal wall fascia have found that delayed closure resulted in stronger fascial tissue than primary closure (Johnson et al 1982). The strength noted in the healing process was attributed to collagen type. Weaker wounds have a higher rate of type three to type one collagen (Johnson et al 1982).

Dressing wounds with sugar was a standard practice in ancient times. Actual Egyptian medical texts dating back to 2600 BC mentioned sugar in at least 900 remedies. During wartime, honey has been used as an antiseptic for wounds even as late as World War I (Mathews and Binnington 2002). In this wound, we applied a 50 percent dextrose solution to the tissues. Dextrose has been associated with several healing properties (Mathews and

Binnington 2002; Ghaderi and Afshar 2004). Concentrated sugar has a fatal effect on bacteria. In a hyperosmotic environment, the bacteria become dehydrated as fluid from their cytoplasm is drawn out to the environment (Ghaderi and Afshar 2004). The dextrose also draws macrophages to the wound (Ghaderi and Afshar 2004). The movement of these cells to the wound can expedite wound clean up and healing. Dextrose provides a local cellular energy source and accelerates the sloughing of devitalized tissue (Mathews and Binnington 2002). One study looked at the effects of several different sugars on wounds and found some, like dextrose, cause a significant increase in accumulation of granulation tissue and may enhance wound healing (Kossi et al 1999). However, some sugars, like mannose, actually inhibit wound healing and inflammation by reducing the number of leukocytes (white blood cells) in wound fluid (Kossi et al 1999).

*Figure 3. Bandaging was difficult because of the location of the wound. Here is an example of the bandage in place. The leg is wrapped where the IV catheter is placed.*

Chlorhexidine was also used as a method for wound disinfection. Chlorhexidine is a bisbiguanide compound with rapid bacterial activity against both Gram–positive and Gram–negative organisms. The antibacterial effects are related to its ability to bind the bacterial cell membrane and cause leakage of cellular contents. This can lead to either impairment or death of the microbe (Sanchez et al 1988a). The goal of disinfection for a surgical wound is to destroy microbes colonizing the wound without inhibiting the healing processes. An in vitro study on dogs showed fibroblast survival at chlorhexidine concentrations less than 0.013 percent; however, bacteria such as *Staphylococcus aureus* survive at chlorhexidine levels as high as 0.05 percent (Sanchez et al 1988b). Conversely, in another study the same researchers showed that in vivo chlorhexidine at 0.05 percent was not cytotoxic to tissue fibroblasts and did not interfere with wound healing; in fact, the disinfectant allowed more rapid healing than saline alone and quicker contraction and sustained residual activity for six hours after irrigation (Sanchez et al 1988b). The authors similarly used chlorhexidine at 0.05 percent concentration (2% diluted 1:40). The plan for this case was to incorporate both chlorhexidine and dextrose, based on previous research suggesting that this combination could be used to significantly reduce the bacterial population in the wound and prevent sepsis (Sanchez et al 1988a).

Silver has long been known to have antimicrobial properties (Wright et al 1998; Wyatt et al 1990; Kuroyanagi et al 1992, Ip et al 2006). A recent study in the *Journal of Medical Microbiology* found that silver–impregnated dressings had excellent bactericidal activity against Gram–negative bacteria and moderate activity against Gram–positive organisms (Ip et al 2006). Rapid bactericidal action permits wound healing to proceed without bacterial interference and reduces the likelihood of resistance (Ip et al 2006). Silver sulfadiazine cream is a water–based cream with a broad spectrum of activity that includes fungal organisms. This compound enhances re–epithelization but may impede wound contraction (Ip et al 2006; Wright et al 1998; Meaume 2005). Oil–based creams should be avoided on bird skin because they can affect the insulating properties of the feathers. In this case, the cream was also found to prevent wound dessication.

Preparation H® is a live yeast cell derivative that enhances wound angiogenesis, epithelization, and collagen synthesis. Live yeast cell derivatives are used to treat granulating wounds in avian patients, especially pododermatitis in raptors (Kuroyanagi et al 1992). This product was used to manage this case with the hope that it would restimulate blood vessel development in the peri–cloacal tissues.

**Wound healing in birds.** Wound healing in birds is generally classified into three stages: inflammatory phase, reparative phase, and maturation phase. Research into the wound–healing cascade in birds is sparse. Information regarding the subject is primarily derived from chicken studies. The inflammatory phase occurs immediately after the initial insult, and is associated with the release of vasoactive molecules that initiate the inflammatory cascade. Recently, the chicken chemotactic and angiogenic factor (CCAF) was identified as a major component of the cellular cascade (Ferrell et al 2002). This compound is homologous to interleukin–8 (IL–8) in mammals. While IL–8 is chemotactic for neutrophils in mammals, CCAF is chemotactic for monocytes and lymphocytes and promotes angiogenesis. This factor is expressed throughout the proliferative phase (Ferrell et al 2002).

The vascular response in birds has a much longer permeability phase; 48 hours compared to 30 minutes in mammals. Heterophils and basophils, rather than neutrophils, predominate in the first 12 hours after injury (Ferrel 2002; Burke et al 2002; Riggs and Tully 2004). The absence of myeloperoxidase in avian heterophils results in a difference in abscess formation between birds and mammals (Ferrell et al 2002). Myeloperoxidase is associated with the mammal's ability to generate liquefactive abscesses. The absence of myeloperoxidase in birds leads to a more caseous abscess. After two to three days, the fibroblasts appear in the wound bed marking the end of the inflammatory phase (Ferrell et al 2002; Burke et al 2002; Riggs and Tully 2004).

The repair stage of wound healing is initiated by the release of cellular and chemical mediators elicited by the inflammatory phase (Ferrell et al 2002; Riggs and Tully 2004). A proliferative response is seen in fibroblastic, endothelial, and epithelial cells surrounding the injury. First, macrophages start to dissolve away any fibrin deposited in the wound, secrete collagenases to break apart connective tissues, and release cytokines to stimulate fibroblastic activity (Ferrel 2002; Burke et al 2002; Riggs and Tully 2004). After approximately three days, endothelial cells begin to proliferate. Wound contraction occurs, but is not as dramatic in birds as in mammals. Unlike mammals, no mast cells are identified in avian granulation tissue to help support the process (Ferrell et al 2002). The final stages occur when the epithelial cells migrate over the collagen matrix to cover the wound (Ferrell et al 2002).

Wounds mature as cross–linking and remodeling of the collagen in the wound bed continues (Ferrell, 2002). Fibroblasts proliferate at about 18 hours and granulation tissue matures at seven to ten days. Collagen appears at three to four days. Collagen maturation in avian species appears to take only weeks, compared to weeks to months in mammals. Granulation tissue becomes relatively avascular and acellular with full histological maturation around 10 days (Ferrel 2002).

## Conclusion

Bandaging the goose was difficult, as it attempted to remove the bandage to access its (absent) uropygial gland. The wound was completely closed 28 days after initial presentation, and the patient was confined to land due to the loss of the uropygial gland. The bird was re–assessed at one and two months post–discharge, and the wound was completely healed (Figure 4). The bird was going to be kept in protected captivity because of the loss of the uropygial gland. Interestingly, the bird had escaped its enclosure and joined another captive Canada goose. The captive goose was observed by the caretaker preening the injured bird. After these preening sessions, the injured bird was found capable of swimming and floating.

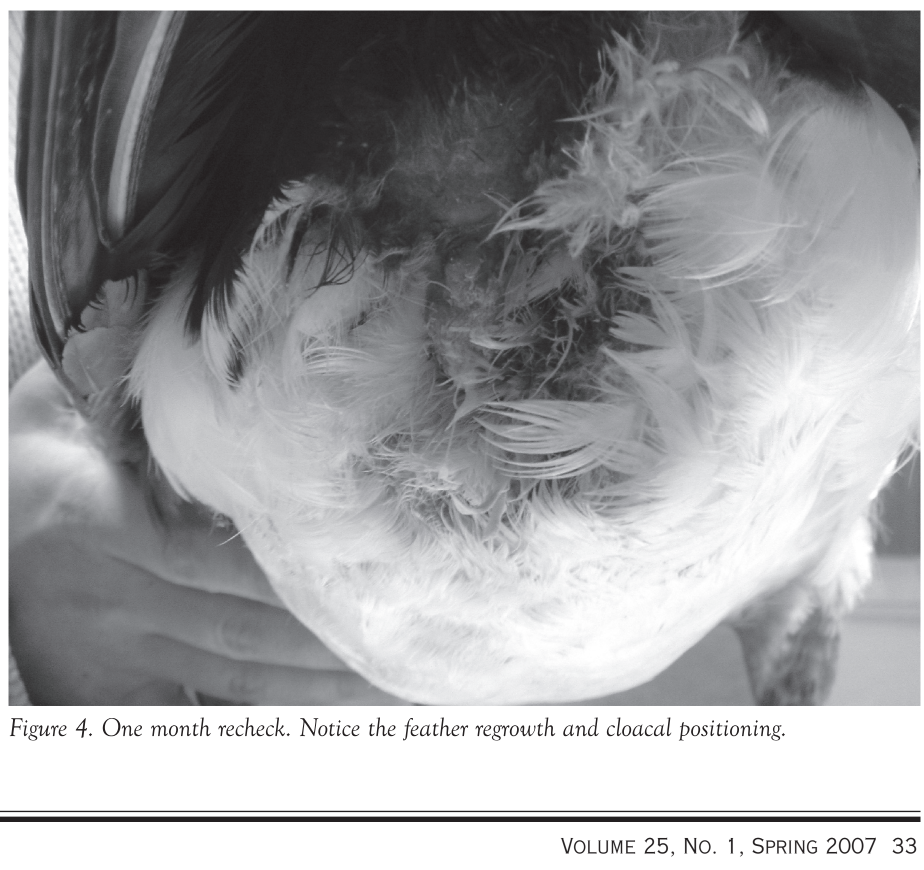

*Figure 4. One month recheck. Notice the feather regrowth and cloacal positioning.*

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