Methicillin-Resistant *Staphylococcus Aureus* Skin and Soft Tissue Infection in a Wild Eastern Grey Squirrel (*Sciurus carolinensis*): A Case Study

Jennifer N. Niemuth and Anthony A. Pilny

**Introduction**

In humans, invasive methicillin-resistant *Staphylococcus aureus* (MRSA) disease is significantly related to healthcare, with approximately 85% of infections associated with the healthcare system (Klevens *et al.* 2007). Intercontinental spread of MRSA strains, and community-associated MRSA strains that have become more virulent, have recently been documented (Taiwo 2009).

Invasive MRSA infections pose multiple treatment challenges and can be fatal. MRSA is now considered an important pathogen in veterinary medicine and, while infections in pets remain uncommon, they are becoming more frequent (Weese 2005). Animal risk factors for MRSA infection are similar to the factors associated with human hospital-associated MRSA infections (Duquette and Nuttall 2004). Cases in dogs (*Canis lupus familiaris*) and horses (*Equus ferus caballus*) appear to be over-represented (Middleton *et al.* 2005), but MRSA has also been documented in cats (*Felis catus*), a guinea pig (*Cavia porcellus*), rabbit (*Order Lagomorpha*), turtle (*Order Testudines*), bat (*Order Chiroptera*), parrot (*Order Psittaciiformes*) (Walther *et al.* 2008), and a captive elephant calf (*Loxodonta africana*) (CDC 2009). Considerable differences have been documented between human, and some animal, MRSA strains (Loeffler and Lloyd 2010), but other strains from dogs and cats appear identical to human hospital-associated MRSA strains (Leonard and Markey 2008). While there is limited information on zoonotic transmission, there is evidence that it can occur (Loeffler *et al.* 2005; Leonard and Markey 2008; CDC 2009; Faires *et al.* 2009). In The Netherlands, MRSA from an animal reservoir, likely pigs (*Sus* spp.) or cattle (*Bos primigenius*), is accountable for greater than 20% of all human MRSA infections (van Loo *et al.* 2007).

**Case Study**

A sub-adult, sexually intact female eastern grey squirrel (*Sciurus carolinensis*) was presented to the Animal Specialty Center in Yonkers, New York, United States for surgical treatment of a left femoral fracture. The squirrel was found, after she had fallen, by a park ranger in City Hall Park, New York, NY. The squirrel was given to a wildlife rehabilitator and was presented to one of the authors (A.A.P.) for evaluation. Physical examination revealed that the squirrel was mentally inappropriate, had caudoventral abdominal and inguinal soft tissue swelling, and had a distal left femoral fracture. One week after surgical fixation of the fracture, the squirrel was found to have an abdominal abscess, as well as a skin and soft tissue infection, at the surgical site. Culture revealed methicillin-resistant *Staphylococcus aureus* (MRSA). The squirrel was treated with antimicrobials, daily wet-to-dry bandages, and supportive care. The left femur was amputated 21 days after the initial surgery. The squirrel made a full recovery. MRSA infection is becoming increasingly important in all areas of veterinary medicine. Appropriate hygiene and biosecurity measures should be taken in all cases when bacterial infection is suspected, and MRSA should be considered as a differential diagnosis. Due to the increasing human–wildlife interface, MRSA infections should also be considered among the differentials for all wildlife cases.

**KEYWORDS:** Eastern grey squirrel, methicillin-resistant *Staphylococcus aureus*, MRSA, *Sciurus carolinensis*.

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**ABSTRACT:** A sub-adult, sexually intact female eastern grey squirrel (*Sciurus carolinensis*) was examined at the Animal Specialty Center (Yonkers, New York, USA) because of injuries sustained during a fall. The squirrel was mentally inappropriate, had caudoventral abdominal and inguinal soft tissue swelling, and had a distal left femoral fracture. One week after surgical fixation of the fracture, the squirrel was found to have an abdominal abscess, as well as a skin and soft tissue infection, at the surgical site. Culture revealed methicillin-resistant *Staphylococcus aureus* (MRSA). The squirrel was treated with antimicrobials, daily wet-to-dry bandages, and supportive care. The left femur was amputated 21 days after the initial surgery. The squirrel made a full recovery. MRSA infection is becoming increasingly important in all areas of veterinary medicine. Appropriate hygiene and biosecurity measures should be taken in all cases when bacterial infection is suspected, and MRSA should be considered as a differential diagnosis. Due to the increasing human–wildlife interface, MRSA infections should also be considered among the differentials for all wildlife cases.

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were obtained. Both areas were flushed with copious sterile saline. Radiographs revealed that the abscess did not communicate with the caudoventral abdomen at the site of previous swelling. Radiotherapy was administered at a dose of 26 ml/kg as a subcutaneous injection. Recovery from anesthesia was without complication and the patient was discharged to the rehabilitator later that day with instructions to keep exercise restricted. Meloxicam and sulfamethoxazole-trimethoprim were continued as previously prescribed.

Seven days post-operatively, the squirrel was seen for a recheck examination and a bandage change. The squirrel had become lethargic and had stopped self-feeding. Physical examination revealed dehiscence of the surgical site, necrosis and infection of the soft tissue and skin, and exposure of the femur and intramedullary pins. An open, draining abscess was also discovered on the caudoventral abdomen at the site of previous swelling. Radiographs revealed that the abscess did not communicate with the peritoneal cavity. Aerobic cultures of the surgical site and abscess were obtained. Both areas were flushed with copious sterile saline and a soft, padded bandage was placed. The patient was discharged with doxycycline monohydrate (Vibramycin; Pfizer Labs, New York, New York USA) at a dose of 5 mg/kg p.o. q12h pending culture results. Meloxicam and sulfamethoxazole-trimethoprim were continued as previously prescribed.

Ten days post-operatively, the squirrel was again seen for a recheck examination and a bandage change. Physical examination revealed no significant change from the previous exam (Fig. 1). The intramedullary pins were removed. Necrotic tissue from the abdominal abscess was debrided and both wounds were flushed with copious sterile saline. Wet-to-dry bandages were placed over the wounds and the squirrel was admitted to the hospital for supportive care and daily bandage changes with planned amputation.

Culture results of both wounds revealed infection with MRSA. Resistance was reported by the reference lab (Antech Diagnostics, Lake Success, New York, USA) for ampicillin, amoxicillin/clavulanic acid, cephalothin, and methicillin. Susceptibility was reported for chloramphenicol, clindamycin, erythromycin, enrofloxacin, gentamicin, neomycin, sulfamethoxazole-trimethoprim, and marbofloxacin (Antech Diagnostics). Treatment with enrofloxacin (Baytril; Bayer Corporation, Shawnee Mission, Kansas USA) at a dose of 5 mg/kg p.o. q12h was initiated, and two doses of buprenorphine HCl at a dose of 0.05 mg/kg in a subcutaneous injection every 8 hr. Doxycycline monohydrate and meloxicam treatment was continued. sulfamethoxazole-trimethoprim treatment was discontinued due to lack of a clinical response, despite favorable in vitro sensitivity.

Wet-to-dry bandages were changed daily for the next four consecutive days, remained unchanged for 3 days, and then were changed daily for an additional two consecutive days. At that time, healthy granulation tissue was noted in both wounds and purulent discharge had ceased.

Twenty-one days post-operatively, the squirrel was re-anesthetized using the same protocol. A mid-diaphyseal left femoral amputation was performed. The muscle was closed by use of 3-0 polydioxanone (Ethicon, Inc.) in a simple interrupted pattern. The skin was closed by use of 4-0 poliglecaprone (Ethicon, Inc.) in a continuous subcuticular pattern and with stainless-steel skin staples (Teleflex Medical, Research Triangle Park, North Carolina USA). A soft, padded bandage was placed on the affected limb. A balanced electrolyte solution (Normosol-R; Hospira, Inc., Lake Forest, Illinois) was administered at a dose of 26 ml/kg as a subcutaneous injection. Recovery from anesthesia was without complication and the patient was discharged to the rehabilitator later that day with instructions to keep exercise restricted. Meloxicam and sulfamethoxazole-trimethoprim were continued as previously prescribed.

Figure 1. Photograph of a MRSA-infected squirrel 10 days post-operatively and prior to initiation of treatment with wet-to-dry bandages and the addition of enrofloxacin to doxycycline treatment. At this time, the intramedullary cross-pins had been removed.

Discussion
Currently, there are no documented reports of MRSA infection in free-ranging wildlife that is free from human contact. MRSA has been found in black rats (Rattus rattus) living on pig farms in The Netherlands (van de Giessen et al. 2009). Methicillin-sensitive
S. aureus strains have been reported in wildlife that are in contact with humans; specifically exudative, ulcerative dermatitis in red squirrels (Sciurus vulgaris) commonly fed by humans in the United Kingdom (Simpson et al. 2010a, Simpson et al. 2010b).

In our specific case, we suspect that the squirrel was already infected with MRSA when it was rescued. The caudal abdominal swelling observed upon initial physical examination was thought to be due to traumatic injury and steatitis but, in retrospect, was likely inflammation associated with the early, invasive MRSA infection. None of the humans involved in this case are known MRSA carriers. No other cases of MRSA infection were being treated concurrently in the hospital. Previous cultures of various areas of the surgery department were negative for any aerobic bacteria. Human interaction with wildlife through supplemental feeding is a common practice in New York City parks and is possibly the source of infection for this squirrel.

Appropriate antimicrobial therapy, wound care, and supportive therapy were the basis of treatment for this case. The use of wet-to-dry bandages facilitated both wound debridement and the establishment of a granulation bed, but also required 11 days of treatment before the wound was healthy enough to safely attempt femoral amputation. For future cases, the use of vacuum-assisted closure may provide a shorter treatment interval which could make limb salvage possible. Additionally, the use of a topical, controlled-release antimicrobial microsphere product could prevent post-surgical wound infection (Fallon et al. 1999).

In the authors’ experience, an unusual number of the grey squirrels that are presented for evaluation by local rehabilitators have neurological abnormalities of varying severity. In the majority of cases, no causative agent or etiology is identified despite diagnostic testing including imaging, biochemical analysis, and toxicologic and serologic screening as well as necropsy and histological examination. Empirical treatment has been attempted for a variety of conditions such as vestibular disease, hepatic encephalopathy, diabetic ketoacidosis, and parasitosis (e.g., Baylisascaris procyonis, Toxoplasma gondii) with no consistent results. In this case, it was suspected that the neurologic symptoms were related to the initial head trauma. The squirrel’s eventual full recovery may support this hypothesis.

Management Implications

Education of clients and staff is the most important step in preventing the further spread of MRSA infections. Our patient was hospitalized in an isolation suite with an established protocol by which the technical staff used appropriate personal protective equipment and biosecurity measures. The client was instructed on proper disinfection protocol, i.e., to wear gloves while treating the patient, to avoid touching their own face after touching the patient or contaminated items, and to prevent the patient’s belongings from being used for other patients at the rescue center.

MRSA infection is becoming increasingly important in all areas of veterinary medicine, and we believe this topic directly relates to the American Veterinary Medical Association’s (AVMA) recently established One Health Initiative (AVMA 2011). The main purpose of this task force is to help with the treatment and prevention of cross-species disease transmission and medical conditions. Appropriate hygiene and biosecurity measures should be taken in all cases when bacterial infection is suspected, and MRSA should be considered as a differential diagnosis. Due to the increasing human–wildlife interface, MRSA infections should also be considered among the differentials for all wildlife cases. The difficulties of treating invasive MRSA infections can be compounded when the patient is a wild animal. Education of staff and clients is essential to treating the individual patient as well as in preventing further spread of MRSA. Further studies focusing on bidirectional transmission of pathogens such as MRSA, and their impact on human, domestic animal, wildlife, and environmental health, will be imperative to our One Health Initiative.

Literature Cited


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**Jennifer Niemuth**, DVM received her DVM at the University of Wisconsin–Madison School of Veterinary Medicine. She completed internships at the Animal Emergency and Referral Center in Northbrook, Illinois, USA (rotating small-animal internship) and at the Animal Specialty Center in Yonkers, New York, USA (avian and exotic pet medicine and surgery internship). Jennifer is currently a doctoral student in North Carolina State University’s joint College of Veterinary Medicine and Fisheries, Wildlife, and Conservation Biology graduate program. Jennifer’s areas of interest include wildlife conservation and zoo and wildlife medicine.

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