Case Report

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Treatment of a California Sea Lion Bite Using Antibiotics and Chlorine Dioxide Solution During a Remote Expedition

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Abstract

Biologists, trainers, and tourists have sustained injuries from interacting with sea lions. Sea lion bites can be serious and compromise health due to mechanical damage to tissues and infection. In this case study, we describe the management of a severe forearm injury in a 29-year-old man resulting from the bite of an adult California sea lion (*Zalophus californianus*) during a research expedition to the Sea of Cortés in 2020. Treatment included hemostasis, sutures, oral antibiotics, and oral chlorine dioxide (ClO_2) solution to promote wound regeneration. Recovery and wound repair progressed rapidly, with wound margin contraction evident 12 hours after the incident and tissue remodeling nearly complete by 3 weeks. There was no evidence of inflammation, infection, or observable sequelae.

Keywords: sea lion, bite, wound, chlorine dioxide, injury, pinniped, treatment, wilderness

Introduction

Field biologists, trainers, hunters, and tourists have been known to sustain bites from sea lions. During the handling of sea lions, small bites on the fingers or arms are common. Most minor bites are not serious and can be easily treated in the field with antiseptics. However, adult sea lions have a strong bite force. (1) Large bites pose serious risks if not treated promptly and appropriately. (2, 3) These risks include blood loss, damage to muscle and connective tissue, which may limit range of motion, and infection with *Mycoplasma* spp, which can lead to cellulitis, inflammation, and osteomyelitis. (4, 5) *Mycoplasma*-associated osteomyelitis, known as "seal finger," may require amputation depending on severity. (6)

The medical literature contains reports on pinniped bites and their treatment in hospitals and healthcare centers. (7) However, there are no reports on treating serious bites in remote locations with limited access to medical care and restricted drug availability. Here, we present a case report of a 29-year-old man who was bitten by an adult female California sea lion (*Zalophus californianus*) during a research expedition to the Sea of Cortés in August 2020.

Case Report

During an attempted capture of adult female sea lions at Granito rookery (29.564595°N, 113.539445°W) in the Gulf of California, a team member was bitten on the forearm near the antecubital fossa while throwing a net over one of the animals. The bite caused two deep lacerations, tearing

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muscle fibers and exposing the radius, with heavy bleeding from the median cubital and cephalic veins. A less severe third laceration, caused by the left inferior canine tooth, was noted over the skin of the extensor carpi ulnaris muscle.

Immediately after sustaining the injury, the subject yelled for help and fell to the ground. Emergency care was provided immediately by other team members, who applied direct pressure to the wounds. Due to insufficient hemostasis after 1 minute, a kaolin-based clotting agent (QuikClot gauze) was used while maintaining direct pressure.

The patient was transported by motorboat to the research vessel. On physical examination, he was alert and conscious, with tachycardia (pulse rate: 108 bpm) and no signs of tachypnea. The closest location, Bahía de Los Ángeles, was 8 hours away and lacked a cellphone signal, landline access, a hospital, or a formal medical clinic. The next closest area with medical attention, Guerrero Negro (Southern Baja California), was even further away. Based on this information, we decided to provide necessary medical attention on board and sail north toward San Felipe (Northern Baja California), where specialty medical care could be provided. No other team members sustained injuries during the incident.

The patient was administered painkillers (paracetamol, 375 mg, and tramadol, 37.5 mg). Subcutaneous injections of 1% lidocaine (3 mg/kg) were administered around the wound margins before irrigation with a sterile 0.9% saline solution to dislodge sand grains. The affected zones were then cleaned with povidone-iodine (PVP-I), also known as iodopovidone. Each wound was sutured in layers using Vicryl (4-0), and the skin was closed with interrupted nylon (3-0) sutures (**Figure 1**). All procedures were conducted aboard the ship by a veterinarian who was also certified as a paramedic and trained in expedition medicine.

Current medical literature recommends high doses of tetracycline to reduce the risk of concurrent *Mycoplasma* infections after pinniped bites. (8, 9) However, because the bite exposed the radius, the risk of osteomyelitis or sepsis was a major concern. These conditions can be more serious than "seal finger," and the recommended prophylactic treatment is oral amoxicillin (250 mg) and clavulanate (62.5 mg) every 8 hours. (10, 11) According to *Stockley's Drug Interactions* (2012), the therapeutic efficacy of amoxicillin can be decreased when used in combination with tetracycline, precluding its use for this patient.

We had brought chlorine dioxide (ClO_2) at a concentration of 3000 ppm on the expedition to purify water and disinfect fresh produce. ClO_2 disrupts bacteria cell walls, leading to cell destruction. (12) It has been used to purify drinking water and disinfect produce, (13, 14) as well as in endodontic antibacterial therapy. (15) Furthermore, ClO_2 has been shown to reduce inflammation by altering the expression of key genes involved in modulating the inflammatory responses when administered at low doses. (16) These doses are at least 1 order of magnitude below the toxicity threshold. (17, 18) We explained to the patient the antibiotic and antiseptic effects of ClO_2 at low doses, (19) as well as its reported safety profile and potential adverse effects, and obtained his consent to receive oral ClO_2 (3 mg in 100 mL of drinking water, yielding a concentration of 0.03 mg/mL) every hour for 8 hours. The total daily dose was 24 mg.

The patient's temperature was recorded hourly for the first 24 hours. We also monitored changes in wound appearance and observed for nausea, vomiting, diarrhea, abdominal pain, headache, skin rash, and itching—adverse effects that have been reported with both amoxicillin-clavulanate and ClO_2. (20, 21) After 12 hours, the wound margins had begun to contract, and there was no edema, erythema, exudate, or pain at the wound sites (**Figure 2**). Upon arriving at San Felipe 26 hours after the incident, the patient's wounds and condition were stable, so we continued treatment as planned for the remaining 5 days. He was scheduled to be evaluated by a physician in his hometown. The patient reported no pain, so analgesics were discontinued. Initial infection prophylaxis (amoxicillin, clavulanate, and ClO_2) was continued at the same dosage and frequency for the remainder of the expedition. No medication-associated side effects were reported. The wounds and the patient's general condition were monitored 4 times daily.

The three wounds continued to heal, and the only symptom reported by the patient was slight numbness distal to the wound, which appeared on day 4 after the incident. Upon returning to his hometown on day 6 after the incident, the patient was examined by a physician, who discontinued the amoxicillin and clavulanate and prescribed ciprofloxacin (500 mg orally for 3 days), pregabalin (300 mg), and naproxen (500 mg for 5 days) to reduce the numbness caused by nerve injury from the bite. The patient continued oral ClO_2 at the same dose for 2 more days, and the wounds continued to improve without evidence of infection. Sutures were removed 9 days after the incident, on September 3

(**Figure 3**). Nearly complete remodeling of the cutaneous tissue was evident 3 weeks after the incident (**Figure 4**).

As a research team member, the patient was available for long-term follow-up. At the time of publication, 54 months after the incident, he has not experienced any complications.

Discussion

Wound recovery was faster than usual. Acute inflammation due to trauma typically takes days to resolve, while repair of mechanical damage takes weeks, and tissue remodeling can take weeks to months to complete. (22-24) In comparison, the patient had no observable inflammation (redness, swelling, or pain) at or around the wounds after 12 hours. Because this case report describes the experience of a single patient, generalizations about the effectiveness of ClO_2 for wound management cannot be made. However, comparable effects have been observed with the chlorite-based drug tetrachlorodecaoxide (TCDO; $4ClO_2.4Na.O_2.H_2O$), also known as OXO-K993 and WF10, which is molecularly similar to ClO_2. (25, 26) Tetrachlorodecaoxide has been used successfully to promote wound healing in patients with persistent and refractory diabetic foot ulcers. (27, 28) It is likely that the ClO_2 solution used as an adjunct treatment for the bite wounds exerted an immunomodulatory effect, as has been demonstrated in both in vivo and in vitro experiments. (16, 29)

We are aware that the ingestion of ClO_2 as an antimicrobial agent has received ample negative attention from the press and health agencies. (30) Chlorite (formed when ClO_2 is added to water) can oxidize hemoglobin to methemoglobin. (31) This can deplete the glutathione concentration and induce oxidative stress, leading to cellular damage and intravascular hemolysis. (32) Case reports in the literature have documented adverse effects associated with oral intake of ClO_2. However, many of these reports do not specify the dose of ClO_2 ingested by the patient, (33, 34) or they describe dosages exceeding 1000 mg/kg, (35) which is more than 300 times the no-observed-adverse-effect level (NOAEL) of 3 mg/kg per day. (17, 18) Adverse effects are to be expected when the toxicity threshold of any drug or chemical—regardless of its perceived safety—is significantly exceeded.

Even then, the safety profile of oral ClO_2 appears acceptable, (36) and as of this writing, only 11 adverse events reports associated with ClO_2 use are listed in the FDA Adverse Event Reporting System (FAERS) Public Dashboard (data from January 1, 2005, to June 30, 2024). The patient in this case tolerated 24 mg per day for 8 days without any adverse effects or discomfort. This dosage is nearly 10 times lower than NOAEL. Given the remote location with no access to a hospital or medical center for alternative treatments or prompt septicemia care, we deemed the decision to administer low doses of ClO_2—with informed consent—both scientifically and ethically justified. Based on his rapid wound healing, prevention of infection, and lack of any observable adverse effects during administration, we propose that ClO_2 may be a safe, effective, and inexpensive option for treating wounds and post-exposure prophylaxis in remote settings when standard treatments are unavailable.

Some recent promising case studies demonstrate similar effects on tissue repair of skin lesions. (37, 38) However, more research is needed to confirm the efficacy of oral ClO_2 solutions for wound healing, as our observation was based on a single patient, and we lacked any type of control.

Conclusion

While the risk of accidents caused by sea lion bites can be assessed and minimized through proper planning before an expedition and by ensuring personnel are trained in handling the animals, it is virtually impossible to eliminate the risk of injury. This case report demonstrates that the repurposed use of a ClO_2 solution at low doses, in conjunction with antibiotic treatment, promoted wound repair and led to a rapid recovery with no complications and minimal scarring. Controlled studies are necessary to confirm the efficacy of this approach. If proven effective, ClO_2 could be a safe and inexpensive addition to wound management.

Figure 1. Bite wound to the patient's forearm. Following hemostasis and wound cleaning, the area was sutured in layers using Vicryl (4-0) for the muscle and nylon monofilament (3-0) for the skin.

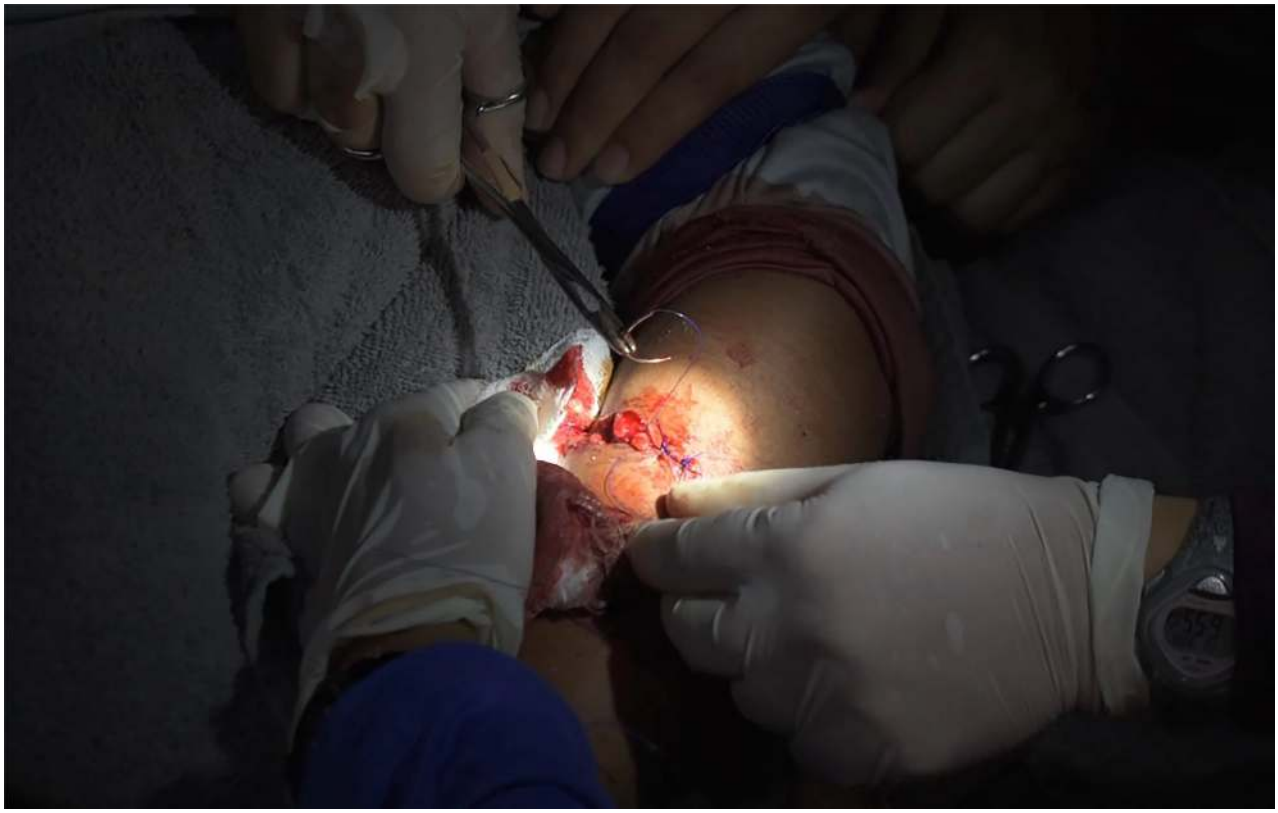

Figure 2. Appearance of two wounds on the anterior forearm. The photograph was taken 12 hours after the incident. The wound margins had begun to contract, and there was no observable edema, erythema, or exudate. At the time of the photograph, the patient had received 1 dose each of paracetamol (375 mg), tramadol (37.5 mg), amoxicillin (250 mg), and clavulanate (62.5 mg), and 8 doses of a ClO_2 solution (each at 0.03 mg/mL) orally.

Figure 3. Appearance of two wounds on the anterior forearm. The photograph was taken 9 days after the incident. At the time of the photograph, the patient had completed a 5-day course of oral amoxicillin (250 mg), clavulanate (62.5 mg) every 8 hours, and a 3-day course of oral ciprofloxacin (500 mg), pregabalin (300 mg), and naproxen (500 mg). He had also taken 8 daily oral doses of a ClO_2 solution (each at 0.03 mg/mL) since the day of the injury.

Figure 4. Appearance of two wounds on the anterior forearm. The photograph was taken 3 weeks after the sea lion bite. The patient had not taken any medication for 11 days when the photograph was taken.

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