CASE REPORT

Moray Eel Attack in the Tropics: A Case Report and Review of the Literature

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As more people use the oceans for recreational purposes, encounters with potentially dangerous sea creatures are becoming more common. We report the case of a scuba diver bitten by a moray eel off the coast of Cuba. The diver received an extensive crush avulsion injury with near loss of his right upper arm. A review of the existing literature identifies the significant characteristics of such attacks. Given the potential seriousness and complications of these attacks, a greater awareness among both treating physicians and emergency personnel may improve overall management of injuries. In addition, greater respect for moray eels among divers and other ocean users may decrease the likelihood of serious eel encounters.

Key words: hand injury, moray eel, scuba

Introduction

Moray eels inhabit the tropic and subtropical waters of the Indian, Pacific, and Atlantic oceans. All eels belong to the order Anguilliformes, which contains 20 families. Moray eels are members of the family Muraenidae, which includes over 100 species. They differ from other eels because they have small rounded gill openings and generally lack pectoral fins. They have no scales, but a layer of mucus covers the body and protects the skin from infection. They may grow up to 3.5 m in length. They have poor eyesight but an excellent sense of smell, which they use to locate food. Although they do not possess fangs or venom as previously thought, their muscular jaws are equipped with strong, sharp teeth that enable them to seize and hold on to their prey (Figure 1A).¹ Their diet consists largely of fish, crustaceans, and other small marine animals.

Although moray eels are traditionally credited with having an aggressive reputation, little information exists to support this. Eel bites reported in the literature typically have been superficial and managed successfully in the emergency-department and outpatient setting.² However, with approximately 80% of the world's population now living in coastal areas, and with more people using the ocean for recreational activities than ever before, en-

counters with hazardous marine animals will undoubtedly increase.³ In this paper, we report the details of a seemingly unprovoked moray eel attack that resulted in a devastating injury to a diver's upper arm, and we review the potential complications and treatment of moray eel bites.

Case Report

A 37-year-old, right-hand dominant, male schoolteacher was attacked by a moray eel while scuba diving on a coral reef close to the Cuban island of Varadero. The diver was dressed in a 'shortie'-type wetsuit, which exposed his forearms and calves. Before entering the water, his diving group was 'briefed' by the instructor regarding the dive and a large 10-year-old green moray eel (*Gymnothorax funebris*) typically encountered on the reef (estimated size of the eel was 1.5 m). It is not clear if previous groups of divers had been feeding the eel. The eel did, however, seem to associate the divers with food, for it emerged to meet them soon after they descended to 30 m. Initially it approached the instructor and a number of other divers before circling the particular diver. Without apparent provocation, the eel seized the volar aspect of the diver's right forearm tightly. The diver made an unsuccessful attempt to summon the attention of his diving group before inflating his buoyancy device and making an emergency uncontrolled ascent to

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A, Green moray eel (*Gymnothorax funebris*). **B**, Intra-operative photograph showing segmental tissue loss from wound. **C**, Right forearm 1 year after the attack. **D**, Right hand attempting to make a fist 1 year after the attack.

the surface. The eel eventually released its grip at a depth of 15 m. Onboard, initial assessment revealed 2 large avulsion wounds on the volar aspect of the right forearm. A cloth tourniquet was placed around the diver's arm to minimize blood loss, and the boat returned to shore 35 minutes later. The diver was taken to the local hospital, where the extent of the injury was evaluated. In spite of the extensive tissue loss to the volar aspect of the forearm, the distal vascularity was intact. The injuries were explored in theater 3 hours after admission, and the following is a summary of the operative findings.

Two segmental areas of skin loss were on the volar aspect of the forearm, proximally 7×3 cm and distally 5×4 cm, with a bridge of intact skin separating them (Figure 1B). The median, ulnar, and radial sensory nerves had been divided at 2 levels. The ulnar artery was divided, but the radial artery was intact. The entire flexor compartment muscles, except flexor pollicis longus, were completely divided at both levels. The muscle bellies to extensor digitorum communis, extensor carpi radialis longus and brevis, and extensor carpi ulnaris were partially divided. After taking wound swabs and performing wound lavage and debridement, the surgeons

repaired the structures. The overlying skin was closed primarily with a drain in situ. The patient was placed in a hyperbaric oxygen chamber to optimize wound healing for 1 hour each day while recovering in Cuba. One week postoperatively, when the patient was judged to be systemically well and was off antibiotics, he was transferred home to his native country. Because the patient reported increasing pain and low-grade pyrexia, we elected to surgically explore his wound on the day of admission. Some residual necrotic muscle was excised, and a split-thickness skin graft was applied to close the wound without tension. He was started on intravenous ciprofloxacin empirically for 24 hours and orally for 5 days. Postoperatively, the pyrexia settled, and hyperbaric oxygen therapy was recommenced for 1 week to optimize wound healing. After a 3-week period of protected mobilization in static splints, a rigorous hand-therapy program was initiated.

At 1-year follow-up, considerable residual disability remained (Figure 1C and D). An advancing Tinel's sign could be elicited at the midpalm level with satisfactory deep and superficial pain sensation. Two-point static discrimination in the fingertips was greater than 15 mm. Despite continuous splinting, a significant claw-hand deformity persisted. Extensive intrinsic muscle wasting was in the hand, along with reduced pinch grip and thumb abduction. The total active range was significantly reduced to 120° in the index finger and 100° in the middle, ring, and little fingers. The patient returned to work 9 months after the injury while still undergoing intensive rehabilitation by the hand therapist.

Discussion

Injuries and illnesses from marine animals fall into 3 categories.⁴ The first and most common group consists of the venomous bites and stings from animals such as sea snakes and jellyfish. The second group consists of animals that are dangerous because of their size or their ability to inflict traumatic injuries. The third group consists of toxic ingestions, resulting in syndromes such as ciguatera or paralytic shellfish poisoning. This case involving the moray eel falls into the second category.

Historically, moray eels have been feared for many reasons. In ancient times, Roman rulers such as Nero were rumored to have thrown disobedient servants into pits filled with ravenous moray eels.² Very little is known regarding the behavioral pattern of adult moray eels, but smaller eels will avoid confrontation and retreat when approached. When they do attack, the wound is inflicted by fanglike teeth and vicelike jaws that lock. It is sometimes necessary to kill an eel or disarticulate its jaws to release its grip.⁵ The roof of a green moray eel's

mouth is equipped with a third row of teeth, which help grasp prey. We do not know of any fatalities to have been reported. Most injuries tend to occur when divers insert their hands into holes occupied by eels or when the eels are attracted by freshly cut fish that the divers carry into the water.⁵ Consequently, hands tend to be the region most commonly bitten. A growing trend of sport divers engaging in hand feeding will undoubtedly lead to an increased number of incidents.

Optimal treatment of a moray eel bite begins in the prehospital phase. All injuries should be referred to a hospital for assessment and determination of tetanus status. Although the risk of developing tetanus is unknown, the practice in our institution is to administer tetanus toxoid for all marine-inflicted wounds if the patient's tetanus immune status is unclear or inadequate. Direct pressure should be applied to any bleeding points, and arrangements should be made to transfer the patient to the receiving hospital. Specialized training in first-aid and trauma management for lifeguards and sport-diving operators should help optimize the patient before transfer.

Wound care in the hospital requires management in the operating theater. Assessment of tendon, vessel, and peripheral nerve injury should be documented. Plain radiographs should be obtained in all injured areas to identify areas of periosteal stripping or particles of teeth, which can remain embedded in bone and act as a source of sepsis if not identified and removed. Wounds should be swabbed for culture. The risk of infection from these injuries is unclear. Erickson et al² reported 3 superficial attacks that all healed uneventfully without wound infection. However, each patient received prophylactic antibiotics at the initial presentation. Irrespective of whether prophylactic antibiotics are given, any early signs of invasive wound infection should be treated promptly. In this case, the presentation of infection was delayed and positive wound cultures were not obtained. The decision to treat empirically with ciprofloxacin was based on the most likely organism present. Contrary to widespread belief, the sea is not a sterile environment for microorganisms.⁶ The majority of marine saltwater bacteria are halophilic gram-negative rods that are facultative anaerobes.⁷ Of particular interest are the *Vibrio* species, which are common in coastal waters and estuaries and have been cultured from captive moray eels.² *V. vulnificus*, *V. parahaemolyticus*, and *V. alginolyticus* are capable of establishing a rapidly progressive cellulitis and have been implicated in life-threatening septicemia and necrotizing fasciitis.^{7,8} Although the choice of antibiotic should be guided by culture and sensitivity if possible, the most common microorganisms cultured from captive moray eels are *Vibrio* and *Pseudomonas*, which are both sen-

sitive to ciprofloxacin, tetracycline, and trimethoprim/sulfamethoxazole.²

The use of hyperbaric oxygen in this setting is controversial. Although a number of controlled studies have shown clear advantages with hyperbaric oxygen in treating certain wounds,^{9,10} the lack of availability together with the risk of adverse effects have limited its use. For optimal wound healing, a high local concentration of oxygen is necessary. Basic processes such as the hydroxylation of amino acids, polymerization and cross linking of procollagen strands, fibroblast and endothelial cell replication, leukocyte killing, and angiogenesis require a PO₂ between 50 and 100 mm Hg.¹¹ In extensive wounds with multiple potentially devitalized structures, the PO₂ may reach only 10 to 30 mm Hg. In addition to raising the local tissue PO₂, hyperbaric oxygen therapy has inhibitory effects on anaerobic bacteria and certain toxin-forming pathogenic microorganisms.^{12,13} Hyperbaric oxygen therapy is especially beneficial to wounds where the nutritive flow and oxygen supply to repair tissues may be compromised but the regional vascular network (essential for oxygen delivery to the tissues) is largely intact.

Although little evidence implicates moray eels as indiscriminate predators, an increased awareness among both emergency-treating personnel and ocean users of the potential severity of moray eel bites should minimize the risk of encounters. Recreational divers entering waters populated by moray eels should be cautioned to avoid direct contact. Since the attack on this diver, 2 subsequent scuba divers from the same region have sustained hand injuries from moray eels. Because little is known to explain why moray eels occasionally bite divers, the accumulation of information from these encounters should continue. This knowledge will enable us to better understand the motivations of these creatures

and subsequently minimize the threat of dangerous encounters.

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