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ORIGINAL ARTICLE

Epidemiology, Clinical Features, and Management of Texas Coral Snake (*Micrurus tener*) Envenomations Reported to the North American Snakebite Registry

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Abstract

Introduction Few of the 5000–8000 snakebites reported to poison control centers annually in the USA are attributed to coral snakes. This study describes Texas coral snake envenomations reported to the North American Snakebite Registry.

Methods All Texas coral snake envenomation cases reported to the registry were identified for the period from January 1, 2015, through December 31, 2019. Data reviewed for this study included details regarding the snake encounter, patient demographics, signs and symptoms, treatment, and outcomes. Descriptive statistics were used to report results.

Results Ten men and four nonpregnant women reported coral snake bites. The median patient age was 15.5 (range 5–72 years). There were 12 upper extremity bites and two bites to the lower extremity. The most common symptoms reported were paresthesias and pain. All subjects had paresthesias, often described as an "electric" sensation. Seven patients described them as painful. The most common clinical findings were erythema and swelling. No patient developed tissue damage, hematotoxicity, rhabdomyolysis, hypotension, weakness, or respiratory symptoms. Thirteen subjects were treated with opioids. Six patients were treated with antiemetics: three prophylactically and two for opioid-induced nausea. One patient developed nausea and nonbloody, nonbilious emesis within 1 hour of the bite, prior to receiving opioids. No patients were treated with antivenom. Antibiotics were not administered to any patient, and no infections were reported.

Conclusions Envenomations from *M. tener* in Southeast Texas are characterized by painful paresthesias. Mild swelling and erythema are common. Neurotoxicity necessitating antivenom or mechanical ventilation did not occur.

Keywords Coral snake · Venom · Envenomation · Snakebite · *Micrurus tener*

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Introduction

There are 5000–8000 snakebites reported to poison control centers (PCCs) annually in the USA, but very few are attributed to coral snakes. The overwhelming majority of bites from venomous snakes are from pit vipers, from the subfamily *Crotalinae*. These snakes, which include rattlesnakes, copperheads, and cottonmouths, were responsible for > 98% of all bites between 2012 and 2017 [1–6].

Three coral snake species accounted for the remainder of bites from native venomous snakes. *Micruroides euryxanthus*, the Arizona, or Sonoran, coral snake, is found in Arizona and western New Mexico. *Micrurus tener*, the Texas coral snake, an example of which can be seen in Fig. 1, is found in Texas, southern Arkansas, and western Louisiana. *Micrurus fulvius*, the Eastern coral snake, can be found in Florida, Alabama, Mississippi, eastern Louisiana, Georgia, and North and

Fig. 1 Texas coral snake, *Micrurus tener*. Photo courtesy of Brittany Kinsey.

South Carolina. There is no overlap in the geographic distributions of the Texas and Eastern coral snakes.

Coral snake envenomations are potentially serious. From 2012 to 2017, 14 (2.9%) of the 481 coral snake bites reported to PCCs caused "major" effects, which means the patient exhibited signs or symptoms as a result of the exposure that were life-threatening or resulted in significant disability or disfigurement. For comparison, 2.15% of copperhead envenomations and 2.28% of cottonmouth envenomations resulted in major effects [1–6].

Clinical manifestations following a coral snake bite may vary depending on the species involved. This study describes the epidemiology, clinical effects, and management of Texas coral snake envenomations using data reported to the North American Snakebite Registry (NASBR), administered by the American College of Medical Toxicology (ACMT).

Methods

The North American Snakebite Registry was established in 2013 as a sub-registry of the Toxicology Investigators Consortium (ToxIC). This consortium is a voluntary, nationwide surveillance, and research tool that prospectively records deidentified patient information from medical toxicologists providing bedside care for patients with a variety of toxicological exposures [7, 8]. Details on data collection within the ToxIC Consortium have been reported previously [7]. The NASBR, which has been described in greater detail elsewhere, represents a subset of ToxIC sites reporting detailed data on snake envenomation across the USA [9].

Data collected in the NASBR include details on the snakebite encounter, patient demographics, circumstances of the envenomation, clinical presentation, diagnostic or laboratory tests, treatment, and any outpatient follow-up or re- admission post-discharge. There are free text fields for each case. Investigators are encouraged to provide additional information as needed to clarify details, which in this series included treatment initiated prior to medical toxicology involvement, methods for measuring objective weakness, and types of analgesics used. The NASBR undergoes centralized data quality oversight by the ToxIC research staff with review of all data entered with follow-up back to sites to resolve missing or incongruous data.

All ToxIC and NASBR data were collected and managed by ACMT using Research Electronic Data Capture (REDCap) tools hosted at the Vanderbilt University Medical Center, Institute for Clinical and Translational Research core [10]. The ToxIC Registry and the NASBR are compliant with the Health Insurance Portability and Accountability Act and do not collect any protected health information or otherwise identifying fields. Registry participation is pursuant to the participating institutions' Institutional Review Board approval and compliance with their policies and procedures. The Registry was also reviewed by the Western IRB and determined not to meet the threshold of human subject research under federal regulation 45 CFR 46 and associated guidance.

For this report, all Texas coral snake (*Micrurus tener*) envenomation cases reported to NASBR were identified for the period from January 1, 2015, through December 31, 2019. Data reviewed for this study included details regarding the snake encounter, patient demographics, local and systemic signs and symptoms, treatment, and outcomes as reported by the single investigator who treated all the subjects. Descriptive statistics were used to report results.

Results

Fourteen Texas coral snake bites were reported to the NASBR from January 1, 2015–December 31, 2019. All were entered into the Registry by one investigator working at two participating sites in Southeast Texas. Although the method of identification is not a required field in the Registry, all cases were entered by the same investigator who used the following criteria to confirm the identity as a coral snake: a photo of the snake or the snake itself was available for identification OR the patient described a snake with red, yellow, and black coloration and exhibited signs and symptoms consistent with a coral snake envenomation.

Ten men and four nonpregnant women reported coral snake bites. All were Caucasian. Nine (64%) patients were younger than 18 years old, with ages ranging from 5 to 72 years old (median 15.5 years old). The bites occurred between the months of March and October, and 13 were transferred to the participating toxicology treatment center from outside hospitals.

There were 12 patients with upper extremity bites: 10 to a finger, one to the hand, and one patient with bilateral hand bites. The two lower extremity bites were on a foot in one patient and a toe in another patient. Neither of the patients bitten on the lower extremity was aware of the snake's

presence prior to being envenomated. Conversely, all but one of the upper extremity bites occurred when subjects knowingly interacted with the snake. Circumstances of the snake encounters are described in Table 1. All but one of the bites occurred in the wild, and none occurred in an occupational setting. Two patients had a history of prior snakebites and were the only two with a history of illicit substance abuse. Three subjects reported alcohol use, but none were intoxicated at the time of the bite. Tobacco use was reported in one subject.

All patients arrived at a healthcare facility within 90 minutes. The most common symptoms reported were paresthesias and pain. All subjects had paresthesias, often described as an "electric" sensation. Seven patients described them as painful, and three rated the pain as "severe." The most common clinical findings were erythema and swelling. Erythema contiguous to the bite site was noted in eight patients, four of whom also had mild swelling. Swelling was not noted in patients without erythema. No patient developed tissue damage (Table 2).

There were no cases of hypofibrinogenemia, thrombocytopenia, prolonged prothrombin time, ecchymosis, bleeding, or rhabdomyolysis. No subjects reported dyspnea or other respiratory symptoms, and intubation and mechanical ventilation were never required. No patients required vasopressors or fluid resuscitation for hypotension.

All patients were monitored with continuous capnography. Serial negative inspiratory force (NIF) measurements were used to assess respiratory muscle strength. Appendicular skeletal muscle strength was quantified via serial dynamometry. No patient had any objective weakness as assessed on multiple evaluations by a single investigator.

Thirteen subjects were treated with opioids. Because the exact medications, dosages, and duration of therapy are not recorded in the Registry, these data are unavailable. Acetaminophen and ketamine were each used in one case. Six patients were treated with antiemetics: three prophylactically and two for opioid-induced nausea. One patient developed nausea and non-bloody, nonbilious emesis within 1 hour of the bite, prior to receiving opioids. Antihistamines were administered in one patient and corticosteroids were given to another patient at the initial hospital for unclear reasons.

Antibiotics were not administered to any patient. Antivenom was available to the treating medical toxicologist. However, because no patients exhibited any signs of weakness, antivenom was not administered. All 14 patients were admitted to the hospital for observation. Eleven patients were discharged within 24 h. The other three were hospitalized for 25–48 h. No patient was admitted to the intensive care unit.

Follow-up information was available for five subjects, ranging from 2 to 14 days (median 10 days). None had prolonged, delayed, or recurrent symptoms or complications. No infections were reported.

Discussion

The presence of paresthesias is consistent with previous studies. A 2007 poison control center (PCC)-based study of *M. tener* bites—including "dry" bites that did not result in

Table 1 Circumstances of snake encounter.

Subject	Age	Sex	Bite location	Intentional interaction?	Circumstances
1	8	M	Finger	No	Patient fell on ground and landed next to snake
2	16	F	Finger	Yes	Bitten while attempting to kill the snake with a machete
3	39	M	Finger	Yes	Patient mistook the coral snake for a nonvenomous snake
4	69	M	Both hands	Yes	Attempted to remove snake from his dining room. Bitten three times on one hand and twice on the other.
5	13	M	Finger	Yes	Bitten while trying to move the snake from the road
6	21	M	Finger	Yes	Bitten while relocating a snake off his property
7	10	M	Finger	Yes	Bitten while trying to move the snake from the road
8	12	M	Finger	Yes	Bitten while trying to liberate a snake his older brother had captured earlier in the day
9	15	F	Foot	No	Walking barefoot at night and stepped on a snake she did not see
10	31	M	Finger	Yes	Bitten while relocating a snake off his property, barehanded
11	11	M	Finger	Yes	On a scouting trip, he was told by more senior scouts that the snake was nonvenomous and safe to handle
12	16	F	Finger	Yes	Patient mistook the coral snake for a nonvenomous snake
13	5	M	Hand	Unknown	Playing outside. Exact circumstances unknown
14	72	F	Toe	No	Bitten by an unseen snake while walking in the dark, wearing flip flops

Table 2 Clinical course.

Subject	Pain	Paresthesia	Swelling	Erythema	Treatment with antiemetic	Treatment with opioid	Other treatment	Length of stay
1	+	+		+		+		< 24 h
2	+	+	+	+		+		25–48 h
3		Transient						< 24 h
4		+	+	+	Yes—for nausea after opioid use	+		< 24 h
5	+	+				+		< 24 h
6	+	+			Yes—prophylactic	+		< 24 h
7		+	+	+		+	Corticosteroids	25–48 h
8	+	+				+		< 24 h
9	+	+	+	+	Yes—prophylactic	+		< 24 h
10	+	+			Yes—prophylactic	+		< 24 h
11		+		+		+		< 24 h
12		+		+	Yes—for nausea after opioid use	+	Diphenhydramine, ketamine	< 24 h
13		+		+	Yes—for emesis prior to opioid use	+	Acetaminophen	25–48 h
14		+				+		< 24 h

envenomation—found that pain was reported in 42.7% of victims [11]. In that population, swelling and erythema were reported in 46.3% and 23.2% of patients, respectively. No patients had skeletal or respiratory muscle paralysis, and there were no deaths. A 1989 case report describes significant paresthesias as well as diplopia despite no erythema, swelling, or wound in a 27-year-old soldier bitten by a Texas coral snake during a training exercise [12].

There are several possible explanations for why we had a higher percentage of patients with symptoms. In the Texas PCC study, only 26.8% of the snakes were positively identified as coral snakes; it is possible that nonvenomous snakes were mistaken for coral snakes. In the PCC study, over half of the patients were treated with coral snake antivenom. This may have prevented development of symptoms in some patients [11]. In our study, the subjects were reassessed frequently by a medical toxicologist with expertise in snakebites; thus, subtle signs and symptoms that may have gone unrecognized in a busy ED or inpatient unit were documented. Finally, 13 of our 14 cases were transfers from community hospitals; there may be a component of referral bias skewing the results.

Historically, Texas coral snake envenomations are less severe than envenomations from *M. fulvius*. In a study of 39 Eastern coral snake envenomations, in addition to swelling and paresthesias, which were reported in 40% and 35% of patients, respectively, the following were observed: emesis (25%), weakness (15%), diplopia (10%), dyspnea (10%), and fasciculations (5%) [13]. Intubation with mechanical ventilation was performed in 15% of patients, and 92% of patients received antivenom.

In a PCC study of 387 patients with *M. fulvius* bites, 218 (56.3%) had no symptoms. Among symptomatic patients, the following were observed: pain (40.6%), paresthesias (28.4%), emesis (11.4%), weakness (6.7%), respiratory depression (3.1%), and paralysis (2.8%) [14]. Additionally, 2.8% of patients were intubated and placed on mechanical ventilation.

Most of the envenomations in our study, including all but one of the bites to the upper extremity, occurred after the victim intentionally interacted with the snake. These results differ from a large NASBR study of primarily crotalid envenomations, in which only 19% of bites and 42.6% of upper extremity bites occurred following intentional interaction with the snake.[9] There are several possible explanations. Crotalids have relatively long, mobile fangs and can deliver venom efficiently. Coral snakes have small, fixed front fangs, and a quick scratch from a fang may not lead to envenomation. Alternatively, crotalids are well camouflaged, and many envenomations occur when victims are unaware of a snake in their vicinity. Coral snakes, however, are brightly colored and are theoretically easier to avoid.

The distinctive coloration has led to several mnemonics that are often used to distinguish coral snakes from nonvenomous mimics. “Red on yellow, kill a fellow. Red on black, venom lack” is often true of native coral snakes, but there are atypical patterns that make reliance solely on the rhyme dangerous. An example of an aberrant coral snake can be seen in Fig. 2. Additionally, some people recite the rhyme incorrectly, placing themselves or others at risk. Furthermore, there are nonvenomous mimics that have red bands touching yellow bands, such as shovel-nosed snakes from the genus *Chionactis*. Finally, non-native coral snakes have a variety of patterns and colors that render the mnemonic inaccurate.

Our patients fared well with supportive care, particularly analgesia. Texas coral snake envenomations have reportedly

Fig. 2 Aberrant Texas coral snake, *Micrurus tener*. Photo courtesy of Spencer Greene, MD.

resulted in ptosis, diplopia, dysphonia, and skeletal muscle weakness [11, 12]. There are no cases of respiratory failure reported in the medical literature. It is possible that some severe envenomations were prevented from progression to respiratory failure with timely antivenom administration. We recommend observing patients for a minimum of 12–18 hours following a Texas coral snake bite with continuous end-tidal carbon dioxide monitoring and serial dynamometry and negative inspiratory force measurements.

The definitive treatment for a significant coral snake envenomation is antivenom, which is recommended for patients with any objective respiratory or skeletal muscle weakness. It is not indicated for local swelling, which is much less significant than the tissue findings observed in crotalid envenomations. Antivenom is also not necessary for paresthesias or pain, which can be treated with oral or parenteral analgesics. Fortunately, antivenom is rarely necessary for *M. tener* envenomations. In our study, no subject had any motor neuron dysfunction. In the 2007 Texas PCC study, 54.9% of patients received antivenom, but in almost all cases, it was given prophylactically. Only 7.3% of subjects had systemic effects, none of which were severe [11].

North American coral snake antivenom (NACSAV) was produced by Wyeth until 2008 [15]. Pfizer acquired the company the following year, and for several years, as the expiration dates for several lots were approaching, the FDA granted approval for extension. NACSAV production resumed as of late 2019. Most hospitals do not keep it in stock. However, supplies may be located using the Antivenom Index, administered by the Association of Zoos and Aquariums and the University of Arizona College of Pharmacy [16].

In the rare instance when NACSAV is warranted but unavailable, there are some potential alternatives. Coralmyn® is a Mexican product that has been recommended by PCCs. However, one study found that it did not effectively neutralize *M. tener* venom [17]. The Costa Rican antivenom produced by the Instituto Clodomiro Picado is also indicated, but not FDA-approved, for North American coral snake envenomations [18].

Mechanical ventilation should suffice for a patient with respiratory failure when antivenom is unobtainable. However, there are no data on this, and it is unknown for how long mechanical ventilation might be necessary. There are also some potential treatments being investigated. Varespladib is an inhibitor of multiple isoforms of phospholipase A_2, and it has demonstrated prolonged survival in murine models of *M. fulvius* envenomation [19]. There are also studies evaluating the effectiveness of the natural immunity to snake venoms exhibited by some mammalian species [20, 21].

Limitations

There are several limitations with this study. Coral snake envenomations are uncommon and thus a small number of cases were included. The cases were all reported from sites in Southeast Texas by a single ToxIC investigator. This may limit applicability to populations in other regions where *Micrurus tener* envenomations occur. Geographic diversities in snake venom within other snake species have been reported and can affect clinical effects of venom in humans [22].

Referral bias may have also affected the results of this study. All patients had signs of envenomation, which is inconsistent with previous reports which have demonstrated about 70–80% envenomation rates for other native coral snake bites [11, 23]. This may have been due to transfer from community hospitals to a tertiary care center in the majority of cases.

A final limitation is that Registry data are observational. Timing of assessment of data points such as clinical and laboratory findings is not controlled, treatment may vary depending on provider practices, and availability of some data is dependent on standard practices at a participating site. In this series, having a single provider mitigated some of these limitations but precluded any corroboration or assurance of accuracy.

Conclusion

Envenomations from *M. tener* in Southeast Texas are characterized by paresthesias that are often painful. Mild swelling and erythema at the envenomation site are also common. Although neurotoxicity necessitating intervention with antivenom or mechanical ventilation did not occur in this study, the small sample size leaves open the possibility that some

patients may require antivenom. A larger study of *M. tener* envenomations would be required to better estimate the need for more aggressive treatment.

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Compliance with Ethical Standards

The ToxIC Registry has approval from the Western Institutional Review Board.

Conflict of Interest None.

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