Wilderness and Environmental Medicine, **12,** 184–189 (2001)

ORIGINAL RESEARCH

Snakebite envenomation in children: a 10-year retrospective review

FRANK LoVECCHIO, DO; DAWN M. DeBUS, MMS, PA-C

From the Good Samaritan Regional Poison and Medical Center, Phoenix Children's Hospital, Department of Medical Toxicology, Maricopa Medical Center, and the Department of Emergency Medicine, Midwestern University, Glendale, AZ (Dr LoVecchio), and Midwestern University, Physician Assistant Master's Program, Glendale, AZ (Ms DeBus).

Objective.—To describe the epidemiology, short-term outcomes, and clinical characteristics of rattlesnake bites (RSB) in children.

Methods.—This was a 10-year retrospective chart review of all patients who were <13 years old admitted to a medical toxicology referral service in a major metropolitan area of the southwestern United States with a diagnosis of RSB.

Results.—Sixty-six children (mean age, 6.33 years) presented to or were transferred to our center with a diagnosis of RSB. Sixty-three percent were male, and the majority of bites (71.93%) occurred on the lower extremities. Forty-nine children (85.96%) developed coagulopathies, and 50 children (87.72%) received Antivenin (Crotalidae) Polyvalent (ACP) administration. Of the 50 children receiving ACP, 19 developed an immediate hypersensitivity reaction. Five cases of morbidity resulted, but no deaths were recorded.

Conclusions.—Serious morbidity is infrequent in children following RSB.

Key words: snakebite, envenomation, antivenom, serum sickness

Introduction

Rattlesnake bites (RSBs) in children are rarely reported. Of the 8000 venomous bites that occur in the United States each year, half involve persons under the age of 20.[1,2] The reported rate of fatalities occurring from envenomation is roughly 1 to 20 per year, with reports of 20% of deaths occurring in children <5 years of age.[1–6] Despite these statistics, envenomation in children is rarely reported in the medical literature. The purpose of this study was to describe the epidemiology, clinical manifestations, and short-term clinical outcome of RSBs in children referred to or presenting to our institution between the years 1988 and 1998.

Pit viper venom is composed of metal ions, biogenic amines, lipids, free amino acids, and approximately 26 enzymes and 69 enzymatic peptides.[1,3] Within a single species, the toxicity of the venom can vary according to the season, geographical area, snake's physical characteristics, and length of time since last strike.[1] Venom is normally deposited in dermal or subcutaneous tissues, but on rare occasions, it can be injected into intravascular or intramuscular tissues.[1,7]

Previously described demographics of RSB envenomation are similar when comparing children and adults. The majority of bites occur between April and October. Snakes are poikilothermic; hence, they are most active during hot weather (27°C–32°C) and during daylight. Previous adult reports note the typical envenomation victim is male (male:female = 9:1), average age of 24 years, and bitten 97% of the time on the extremity. In adults, 85% of RSBs occur on the upper extremities, while in children, 70% occur to the lower extremities.[1–4,7–12] The percentage of upper extremity RSBs in adults correlates with a higher incidence of illegitimate bites and ethanol intoxication.[1,7,12]

Weber and White[13] have suggested that children will sustain a more severe toxicity because of an increased venom:body mass ratio. Conversely, the larger adult body mass may provide a diluent for the snake toxin, theoretically causing a less potent envenomation.[14]

Wound infections from RSBs are rare.[14] The infection is produced not by the venom but by microorganisms within the snake's oral cavity and on human skin. Some

Corresponding author: Frank LoVecchio, DO, 925 East McDowell Rd, 2nd Floor, Phoenix, AZ 85006 (e-mail: frankl@samaritan.edu).

of the most common bacteria isolated from the snake's oral flora include *Salmonella* spp, *Bacteroides fragilis,* and coagulase-negative staphylococci.[1,14] Unconventional first-aid treatment may contribute to infection.[14]

Hematologic abnormalities are relatively common occurrences after pit viper envenomation. Initial laboratory values obtained during hospital management may reveal thrombocytopenia, hypofibrinogenemia, increased fibrin split products, and elevated prothrombin times. The actions of venom proteases, thrombinlike enzymes, and phospholipases induce these changes.[1–3,7,15–21]

Assigning a degree of severity to a bite is a subjective process and is dependent on the caregiver's initial observation. This does not lend itself well to a retrospective study. Furthermore, the severity of a bite may rapidly progress from one degree to the next during any stage of treatment.[19,22] Not uncommonly, a victim may present to the medical facility with a bite that is initially innocuous or showing signs of resolution but produces delayed toxicity.[19]

Several conventional and unconventional methods of treatment are available for prehospital care and hospital management. The safest prehospital approach, assuming no venom anaphylaxis (extremely rare) or hemodynamic instability, is to immobilize and transport the victim to the nearest medical facility without delay.[1,2,7] Nontraditional methods of treatment have included alcohol, amputation, botanical cures, application of saliva, split chickens, or scrapings from crocodile teeth.[1] More recently touted techniques such as the use of tourniquets, incision and suction, cryotherapy, and electric shock therapy are not medically advised and should not be used.[1–3,7,23–27]

By 1954, Wyeth Laboratories (Philadelphia, PA) had begun marketing the first commercially available antivenom for North American pit vipers, Antivenin (Crotalidae) Polyvalent (ACP). ACP consists of serum globulins obtained from healthy horses immunized with the following venoms: *Crotalus adamanteus* (eastern diamondback rattlesnake), *Crotalus atrox* (western diamondback rattlesnake), *Crotalus durissus terrificus* (tropical rattlesnake), and *Bothrops atrox* (fer-de-lance).[3]

Anaphylactic-anaphylactoid reactions and serum sickness may result after ACP administration.[21,28] These reactions may result in nausea, vomiting, abdominal cramps, urticaria, pruritus, hypotension, severe bronchospasm and laryngospasm, bradycardia, and possibly death.[1–4,7,21,28] Serum sickness is a type III hypersensitivity reaction to ACP. This reaction may result in fever, malaise, urticaria, edema, lymphadenopathy, arthralgia, arthritis, and myalgia.[1–4,7]

Materials and methods

This study comprises a 10-year (October 1988–September 1998) retrospective chart review of children (≤13 years of age) presenting to or transferred to a tertiary care, level 1 trauma center in a major metropolitan area of Arizona with suspected rattlesnake bite. Following approval by the Investigation Review Board, a log of snakebites was maintained at the Department of Medical Toxicology for eligible patients. A systematic chart review was subsequently done by 1 investigator (D.B. or F.A.L.). Ten percent of charts were reviewed randomly by a second investigator, and a correlation coefficient was calculated. The following data were collected: age, sex, weight, date of bite, type of snake, whether the snake was wild or captive, area of body bitten, number of times bitten, time before arrival to hospital, prehospital methods of treatment (eg, incision and suction, immobilization, and nothing), clinical manifestations (eg, fang marks, nausea, vomiting, and abdominal pain), hematological manifestations (ie, platelets, fibrinogen, and protime), hospital management (eg, ACP administration and surgery), length of hospital stay, and any resulting sensitivity reactions or morbidity-mortality. If data concerning clinical manifestations were not documented, they were recorded as negative. These data were compiled on a data collection sheet and analyzed using the following descriptive statistics: mean, median, range, percentage, and SD. The data collected were used for statistical purposes only and were not used to identify the children involved in this study.

Results

A total of 66 cases were available for review between October 1988 and September 1998. The average age of the children was 6.33 years (range, 13 months–13 years). Sixty-three percent of the victims were male, and 37% were female. The P value for kappa and 95% CIs for interobserver reliability were $P = .0005$, kappa of .69 with CIs (.44–.95)

As depicted in Figure 1, August and September had the greatest incidence of rattlesnake bites. Of the 66 cases reviewed, 56 (85%) were positively identified as rattlesnake bites. The western diamondback rattlesnake (*C atrox*) is most commonly encountered in our region. Identification was made by a family member who saw the snake or by a physician when the snake was captured and brought to the medical facility. One hundred percent of these bites resulted from snakes in the wild.

Figure 2 demonstrates that the majority of children (73%) were bitten on the lower extremities. The remainder were bitten either on the arm (1 case) or the hand

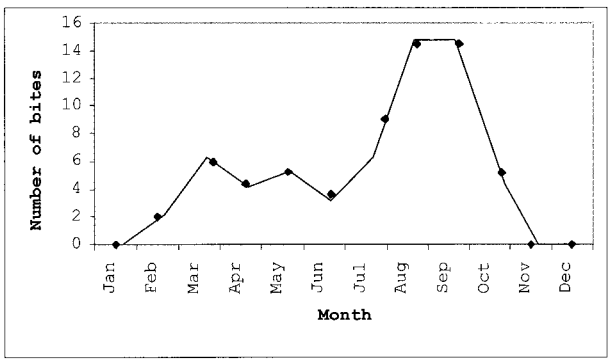

Figure 1. Number of rattlesnake bites treated per month over a 10-year period from 1988 to 1998.

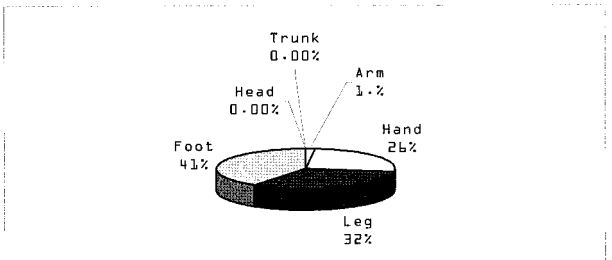

Figure 2. Location of rattlesnake bites in 66 children (presented as percentage).

(17 cases, or 26%). No children were bitten on the trunk or head.

The mean time before obtaining professional medical attention was approximately 2 hours (range, 10 minutes–24 hours). In 3 separate cases, a 7-, 8-, and 10-year-old child was examined at a medical facility other than the hospital designated for this study then released without a diagnosis of RSB. These children reported to the level 1 trauma center 15, 24, and 18 hours later, respectively, with significant clinical manifestations.

Prehospital methods of treatment (as documented on the EMS sheet or hospital record) included use of ice packs (12%), incision and suction (3%), tourniquet (6%), and immobilization (4.5%). Other methods included washing of the site and use of a constriction bandage in 2 cases. No form of prehospital treatment was recorded in ~75% of cases.

Occurrence of local and systemic clinical manifestations is depicted in Table 1. Edema at the site or surrounding tissues was seen in all cases. Local pain (59%) and ecchymosis (56%) were the next most common presenting clinical manifestations. The majority of children (63%) presented without any clinically significant systemic symptoms. Five children experienced multiple general symptoms.

Pertinent laboratory values recorded during the length of hospital stay were obtained for each child and are summarized in Table 2. Initial platelet values were recorded in all but 1 case, and initial fibrinogen values were recorded in all but 12 cases. In addition to initial values, the lowest platelet and fibrinogen values recorded during the hospital course were obtained, and the highest protime values were obtained. Initial platelet values ranged from 26.6 to 496 ($\times 10^3$/mcL) with a median of 141 ($\times 10^3$/mcL). The lowest platelet value obtained during the hospital course was 19 ($\times 10^3$/mcL). The initial fibrinogen values ranged from <15 to 420 mg/dL with a median of 145 mg/dL. The range for the initial protime was 11.2 to 21.6 seconds (median, 14.7 seconds), while the highest protime obtained during the hospital stay was >60 seconds.

In addition to these values, the highest creatine kinase (CK) values were also recorded in 16 of the 66 cases. The mean peak value was 8621 IU/L, with values ranging from 50 to 121 363 IU/L.

Aspects of hospital management reviewed included ACP administration, use of adjunct medications, administration of antibiotics and tetanus booster, surgical procedures performed, and other methods of treatment.

As depicted in Figure 3, the majority of children received ACP. Thirty-three of the 66 children (50%) received 10 to 20 vials, while 26 children (39.4%) received greater than 20 vials. Seven children (12.28%) did not receive ACP.

Adjunct intravenous medications for allergic and anaphylactoid reactions included epinephrine infusion, histamine-blockers, and steroids. Thirty (45.4%) children

Table 1. Clinical manifestations of rattlesnake envenomation in 66 children

Presentation	*No.*	*Percentage*
Local		
Edema	66	100
Pain	39	59
Ecchymosis	37	56
Erythema	11	16.6
Bleeding	9	13.6
Bullae	6	9
Systemic		
Vomiting	11	16.6
Abdominal pain	1	1.5
Diarrhea	1	1.5
Hypotension	1	1.5
None	42	63.6
Other*	11	16.6

*Other includes: inguinal node tenderness, groin pain, pallor, lethargy, hypotension, mottling, decreased sensation, decreased range of motion, tachycardia, capillary refill >2 seconds, and blurred vision.

Table 2. Mean laboratory values obtained during length of hospital stay

	Initial	*Nadir*	*Peak*
Platelet (10^3/mcL)	233.68 ± 112.07 SD	156.50 ± 89.28 SD	NA*
Fibrinogen (mg/dL)	199.24 ± 83.71 SD	138.33 ± 86.39 SD	NA
Protime (seconds)	14.01 ± 2.24 SD	NA	16.09 ± 6.49 SD

*NA indicates not applicable.

received these medications. Of the 30 children, 15 received an epinephrine infusion (typically administered as 1 mg of 1:1000 epinephrine in 250 mL of fluid titated to clinical response), 27 received histamine-blockers, and 20 received steroids. The majority of these children (24 of 30) received combinations of these medications. With regard to antibiotic and tetanus administration, only 3 children received antibiotics, and 7 children received a tetanus booster.

Surgery was preformed in 8 of the 66 cases. The following surgical procedures were performed: debridement of bullae (7 of 8), fasciotomy (3 of 8), and skin graft (1 of 8). One child received all 3 procedures, and another child required both debridement and fasciotomy. Peak compartment pressures for patients with fasciotomy were 41, 55, and 59 mm Hg.

Overall, 7 children did not receive ACP or require any surgical interventions. Documented methods of treatment in these cases included observation and elevation of the affected limb.

The average length of hospital stay was 2 days (range, 1–13 days) as determined by admittance and discharge dates. For analytical purposes, those children admitted and discharged on the same day were entered as 1 day but recorded as less than 1 day on the data collection sheet.

Immediate hypersensitivity reactions (rash, wheezing, etc) to ACP were recorded in 25 of the 66 children (38%) receiving the antiserum. Of these 25 children, 1 experienced hypotension, 1 experienced wheezing, and 18 had a rash. Five cases (8.77%) resulted in the following morbidities: compartment syndrome (3 of 5), contracture of the lower extremity (1 of 5), and decreased range of motion and limp (1 of 5). There were no fatalities.

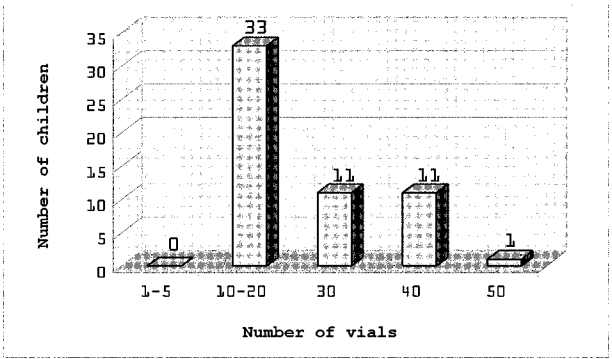

Figure 3. Number of vials of Antivenin (Crotalidae) Polyvalent administered to envenomated children.

Despite only 3 children receiving antibiotics, no wound infections were reported during the hospital stay. The exact incidence of wound infections is unknown, because most patients were followed up after discharge by poison control correspondence or with their primary care physicians.

Discussion

The epidemiological factors for rattlesnake bites occurring in children that were obtained in this study are similar to those reported in the literature reviewed. A majority of envenomations occurred between the months of April and October, with most of the victims being male with an average age of nearly 7 years. Lower vs upper extremity bites, as well as those inflicted by wild snakes (vs captive), were more common in our RSB series.

The local and systemic effects varied, with the most common signs and symptoms being edema, pain, and ecchymosis at the site, and nausea and vomiting. Fifty-eight of the 66 children developed a coagulopathy on arrival at the hospital or during the length of the hospital stay. No reports of nephrotoxicity (short-term) were made over this 10-year period despite a few cases of elevated creatine kinase levels.[21] Neurological symptoms are rare in western diamondback rattlesnake envenomations, which was the most likely involved species in our series.

In only 17 cases was some method of prehospital treatment recorded. Of these, 1 child presented to the hospital with an ice pack and elastic bandage in place (duration estimated to be 90–120 minutes). Mottling at the site was noted. During the course of the hospital stay, a contracture of the lower extremity resulted.

Of the 66 cases, 59 children received ACP, while the other 7 children were observed without antivenom administration. ACP reversed or improved coagulopathy in

all patients who had baseline abnormal coagulation studies. In general, children who did not receive ACP did not have a coagulopathy (1 case received ACP for progressive swelling).

ACP administration is associated with risks. Of the 59 children receiving ACP in this study, 19 (32%) developed an immediate hypersensitivity reaction in which they experienced a rash, wheezing, hypotension, or other symptoms. At the onset of these reactions, all 19 children received variable combinations of epinephrine, histamine-blockers, and steroids and were able to continue with ACP administration. These reactions are more likely anaphylactoid and related to rate of administration as opposed to true anaphylaxis.

Surgery was rarely performed in our series. If surgery was performed, it was typically a minor procedure such as skin grafting or bedside procedures such as bleb removal. Fasciotomy was performed in 3 patients (4.5%) in our series.

Skin testing was documented in 44 of the total 66 cases. In 7 separate cases, children had positive skin tests prior to ACP administration or were known to be allergic to horse serum. In these instances, the children were medicated with epinephrine, histamine-blockers, or steroids prior to receiving ACP and tolerated the infusion without immediate hypersensitivity. Based on the delayed onset of action of steroids, it is unlikely that parenteral steroids prevented immediate hypersensitivity to ACP infusion. Skin testing and prophylactic premedication of every child presenting with suspected snakebite remain debated issues. Future study involving the use of a newly approved antivenom containing ovine fragmented antibodies (CroFab, Protherics Inc, London) may reveal a decrease in the incidence of adverse reactions.[29,30]

The greatest limitation of this study is its retrospective design with its inherent inability to control management variables and ensure accuracy of recorded data. Descriptive studies such as this, however, yield epidemiological statistics and information on clinical manifestations, prehospital care, and hospital management and can serve to generate hypotheses for future, better designed prospective studies. In addition, this study describes 1 institution's experience with bites by venomous snakes in its region and therefore may lack external validity.

References

1. Blackman JR, Dillon S. Venomous snakebite: past, present, and future treatment options. *JABFP*. 1992;5:399–405.
2. Wingert WA, Chan L. Rattlesnake bites in southern California and rationale for recommended treatment. *West J Med.* 1988;148:37–44.
3. Seiler JG, Sagerman SD, Geller RJ, Eldridge JC, Fleming LL. Venomous snake bite: current concepts of treatment. *Orthopedics.* 1994;17:707–714.
4. Jurkovich GJ, Luterman A, McCullar K, Ramenofsky ML, Curreri PW. Complications of Crotalidae antivenom therapy. *J Trauma.* 1988;28:1032–1037.
5. Wagner CW, Golladay ES. Crotalid envenomation in children: selective conservative management. *J Ped Surg*. 1989;24:128–131.
6. Henderson BM, Dujon EB. Snake bites in children. *J Ped Surg*. 1973;8:729–733.
7. Davidson TM. Intravenous rattlesnake envenomation. *J Wilderness Med.* 1988;148:45–47.
8. Parrish HM, Goldner JC, Silberg SL. Comparison between snakebites in children and adults. *Pediatrics.* 1965;36: 251–256.
9. Jamieson R, Pearn J. An epidemiological and clinical study of snake-bites in childhood. *Med J Aust.* 1989;150: 698–702.
10. Tibballs J. Diagnosis and treatment of confirmed and suspected snake bite: implications from an analysis of 46 paediatric cases. *Med J Aust.* 1992;156:270–274.
11. Mead HJ, Jelinek GA. Suspected snakebite in children: a study of 156 patients over 10 years. *Med J Aust.* 1996; 164:467–470.
12. Curry SC, Horning D, Brady P, Requia R, Kunkel DB, Vance MV. The legitimacy of rattlesnake bites in central Arizona. *Ann Emerg Med.* 1989;18:658–663.
13. Weber RA, White RR. Crotalidae envenomation in children. *Ann Plast Surg.* 1993;31:141–145.
14. Clark RF, Selden BS, Furbee B. The incidence of wound infection following crotalid envenomation. *J Emerg Med.* 1993;11:583–586.
15. Burch JM, Agarwal R, Mattox KL, Feliciano DV, Jordan GL. The treatment of crotalid envenomation without antivenom. *J Trauma.* 1988;28:35–43.
16. Moss ST, Bogdan G, Dart RC, Nordt SP, Williams SR, Clark RF. Association of rattlesnake bite location with severity of clinical manifestations. *Ann Emerg Med.* 1997; 30:58–61.
17. Clark RF, Williams SR, Nordt SP, Boyer-Hassen LV. Successful treatment of crotalid-induced neurotoxicity with a new polyspecific crotalid Fab antivenom. *Ann Emerg Med.* 1997;30:54–57.
18. Riffer E, Curry SC, Gerkin R. Successful treatment with antivenom of marked thrombocytopenia without significant coagulopathy following rattlesnake bite. *Ann Emerg Med.* 1987;16:1297–1299.
19. Guisto JA. Severe toxicity from crotalid envenomation after early resolution of symptoms. *Ann Emerg Med.* 1995; 26:387–389.
20. Dart RC, Hurlbut KM, Garcia R, Boren J. Validation of a severity score for the assessment of crotalid snakebite. *Ann Emerg Med.* 1996;27:321–326.
21. Bush SP, Jansen PW. Severe rattlesnake envenomation

with anaphylaxis and rhabdomyolysis. *Ann Emerg Med.* 1995;25:845–848.
22. Huang TT, Lynch JB, Larson DL, Lewis SR. The use of excisional therapy in the management of snakebite. *Ann Surg.* 1974;179:598–605.
23. Simon TL, Grace TG. Envenomation coagulopathy in wounds from pit vipers. *N Eng J Med.* 1981;305:443–447.
24. Stewart ME, Greenland S, Hoffman JR. First-aid treatment of poisonous snakebite: are currently recommended procedures justified? *Ann Emerg Med.* 1981;10:331–335.
25. Guderian RH, Mackenzie CD, Williams JF. High voltage shock treatment for snake bite. *Lancet.* 1986;2:229.
26. Kroegel C, Meyerzum Buschenfelde KH. Biological basis for high-voltage-shock treatment for snakebite. *Lancet.* 1986;2:1335.
27. Dart RC, Gustafson RA. Failure of electric shock treatment for rattlesnake envenomation. *Ann Emerg Med.* 1991;20:659–661.
28. Hogan DE, Dire DJ. Anaphylactic shock secondary to rattlesnake bite. *Ann Emerg Med.* 1990;19:814–816.
29. Consroe P, Egen NB, Russel FE, et al. Comparison of a new ovine antigen binding fragment (Fab) antivenom for United States Crotalidae with the commercial antivenom for protection against venom-induced lethality in mice. *Am J Trop Med Hyg.* 1995;53:507–510.
30. Sullivan JB. Past, present, and future immunotherapy of snake venom poisoning. *Ann Emerg Med.* 1987;16:938–944.