

Target Audience: Emergency Medicine Residents, Medical Students

Primary Learning Objectives:

1. Recognize signs and symptoms of rattlesnake envenomation
2. Order appropriate laboratory studies
3. Recognize indications for antivenom therapy
4. Recognize criteria for dry bites and observation time required
5. Describe the role of poison control centers in rattlesnake envenomation
6. Know how to contact poison control
7. Describe therapies to avoid in the first aid of the envenomed patient

Secondary Learning Objectives: detailed technical/behavioral goals, didactic points

1. Obtain medication history and evaluate for use of anticoagulant medications
2. Describe importance of reevaluation of local effects
3. Describe importance of removing tourniquets that may have been placed prior to arrival in ED
4. Know the 3 types of toxicity that can result from rattlesnake envenomation

Critical actions checklist:

1. Perform rapid assessment looking for signs of anaphylactoid reactions and local, hematologic, and systemic toxicity
2. Elevate the envenomed extremity
3. Remove tourniquet
4. Obtain IV access and evaluate fluid status
5. Order CBC, Fibrinogen, PT/INR, PTT
6. Administer analgesic
7. Call Poison Control
8. Administer antivenom after asking about relative contraindications

Environment:

1. Room Set Up – ED critical care area
 - a. Manikin Set Up – Mid or high fidelity simulator
 - b. Props – Standard ED equipment
2. Distractors – ED noise

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CASE SUMMARY

SYNOPSIS OF HISTORY/ Scenario Background

The setting is a suburban emergency department.

Patient is a 66-year-old female brought to the emergency department by EMS after being bitten by a rattlesnake while gardening in her yard. She was pulling weeds under a small tree when she felt pain to her right hand. She then saw the snake coiled and rattling. She loosely tied a rag around her forearm to stop the venom from spreading.

PMHx: HTN

PSHx: Cholecystectomy

Medications: HCTZ, Acetaminophen PRN

Allergies: NKDA

SocHx: Lives with her husband. Works as court stenographer. Occasional alcohol use. No Tobacco.

SYNOPSIS OF PHYSICAL

Patient is initially anxious, tachycardic.

Airway is intact.

Neurologic exam reveals mild paresthesias, but intact sensation to light touch.

Right hand with ecchymosis. Three puncture marks to dorsum of hand over the fifth metacarpal.

Mild edema to right hand with leading edge just proximal to the wrist

CRITICAL ACTIONS

1. Perform a rapid assessment (must include tourniquet removal)

Perform a rapid assessment of the patient. Recognize signs of local envenomation (edema, erythema, ecchymosis, fang marks) and remove tourniquet.

Cueing Guideline: Nurse can ask if the doctor thinks the rag she tied around her arm will keep venom from spreading. Recognize potential adverse effects of tourniquet removal (e.g. reperfusion injury and shock, release of venom load into systemic circulation and resultant anaphylactoid reaction, etc.) particularly related to duration of time on and degree of constriction.

2. Obtain IV access

Obtain IV access. May give 1 to 2 liters of NS for volume resuscitation.

Cueing Guideline: The nurse may say, "Do you want an IV?" or "Would you like any fluids?" Alternatively, the nurse can mention the tachycardia.

3. Order appropriate labs

Order appropriate labs. Should include CBC, PT/INR, PTT, Fibrinogen.

Cueing Guideline: The nurse can ask if the doctor would like any labs or any levels on the patient.

4. Provide analgesia

Provide analgesia. Administer opioid analgesic.

Cueing Guideline: Nurse can remark that the patient looks uncomfortable or the patient can ask for pain medication.

5. Elevate the right hand above the level of the heart

Elevate the right hand above the level of the heart.

Cueing Guideline: Nurse can ask the doctor if anything can be done to help the swelling.

6. Administer antivenom

Ask about any previous antivenom received, allergies to sheep, allergies to papaya/pineapple.

Cueing Guideline: Nurse can ask the doctor if the antivenom can cause allergic reactions prior to administration.

7. Call Poison Center (PC)

Cueing Guideline: Nurse can ask the doctor if anyone has called the PC yet.

Critical Actions Checklist¹

Resident Name								
Case Description								
Skills measured <small>Core competencies: PC Patient care, MK Medical knowledge, IC Interpersonal and communication skills, P Professionalism, PB Practice-based learning and improvement, SB Systems-based practice</small>	Very Unacceptable		Unacceptable		Acceptable		Very Acceptable	
Data Acquisition (D) PC MK I	1	2	3	4	5	6	7	8
Problem Solving (S) PC MK PB	1	2	3	4	5	6	7	8
Patient Management (M) PC MK IC P PB SB	1	2	3	4	5	6	7	8
Resource Utilization (R) PC PB SB	1	2	3	4	5	6	7	8
Health Care Provided (H) PC SB	1	2	3	4	5	6	7	8
Interpersonal Relations (I) IC P	1	2	3	4	5	6	7	8
Comprehension of Pathophysiology (P) MK PB	1	2	3	4	5	6	7	8
Clinical Competence (C) PC MK IC P PB SB	1	2	3	4	5	6	7	8
Critical Actions								
Yes	No				Comments:			
		Perform a rapid assessment (must include tourniquet removal)						
		Obtain IV access						
		Order appropriate labs						
		Provide analgesia						
		Elevate the right hand above the level of the heart						
		Administer antivenom						
		Call Poison Center						
					Yes	No	Dangerous actions	

¹ Modified ABEM Oral Certification Examination checklist and scoresheet

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HISTORY

You are called to see a new patient (66-year-old female) who was brought to the ED by ambulance. You see a female who appears in pain, but no acute distress.

Onset of Symptoms: Today about 1 hour prior to arrival

Background Info: 66-year-old female is mildly anxious and complaining of pain in her right hand. The patient's husband said he heard her scream while working in the yard. She said she was bitten by a snake, so he called 911. He then killed the snake.

Additional History

From Husband: If asked about the snake, he will provide the specimen in a trash bag

Chief Complaint: Pain to the right hand after snake bite

Past Medical Hx: HTN

Past Surgical Hx: Cholecystectomy

Habits: Smoking: None
ETOH: Occasional
Drugs: None

Family Med Hx: Hypertension, diabetes

Social Hx: Marital Status: Married
Children: 4 adult children
Education: PhD in Classics
Employment: Local University

ROS: Pain to right hand, otherwise negative.

CASE CONTINUATION

Shortly after patient is triaged into the ED, the nurse requests an order for pain medication

**Vital Signs: BP: 154/90 mmHg P: 115/minute R: 18/minute T: 37C (98.6F)
POx: 98% (room air)**

Primary Survey

Airway – Patent

Breathing – Mild tachypnea, 98% POx

Circulation – Tachycardia (110's), SBP 150's

Disability – Patient is mildly anxious. Awake and alert. Paresthesias to right hand.

Exposure – Obvious ecchymosis and edema to right hand

Required Action

- Establish safety net (IV, oxygen, cardiac monitor, two large bore IVs, draw blood for labs)
- A/B – No intervention necessary
- C – cardiac monitor; 1-2L NS IV bolus for presumed volume depletion; ECG
- D – labs are sent

Branch Point

- **IF NO INTERVENTION OCCURS WITHIN THE FIRST TWO MINUTES**, tachycardia increases to the 130s.

PHYSICAL EXAM

General Appearance: Appears stated age. Appears in pain.

Vital Signs: BP: 154/90 mmHg P: 110/minute R: 18/minute T: 37C (98.6F)
POx: 98% (room air)

Head: Normal

Eyes: PERRLA, pupils 3 mm bilaterally

Ears: TM's normal

Mouth: No trauma, moist mucous membranes and lips

Neck: No tenderness or deformity on exam, full range of motion

Skin: Moist skin, no rashes, warm

Chest: No respiratory distress

Lungs: Clear, equal bilaterally

Heart: Tachycardic, S1 S2, no murmurs

Back: Normal

Abdomen: Soft, non-tender, no signs of trauma, no rebound/guarding

Extremities: Diffuse edema and ecchymosis to right hand just proximal to the wrist. 3 puncture marks with dried blood to the dorsal aspect of the 5th metacarpal. Decreased range of motion secondary to pain and edema. Diffuse paresthesias to the hand. Palpable radial artery pulse.

Genital: Deferred

Rectal: Deferred

Neurological: Paresthesias to right hand

Mental Status: Alert and oriented to person, place, time, and situation

Required Actions

- Removal of tourniquet
- Opioid analgesic medication
- Contact poison control

Branch Point

- **IF TOURNIQUET IS REMOVED**, patient reports improvement in paresthesias.
- **IF ANALGESIA IS ADMINISTERED**, patient reports improvement in pain.
- **IF POISON CENTER IS CALLED**, recommendation for antivenom administration (4-6 vials) is made.

CASE CONTINUATION

- Pain improved
- Antivenom therapy (4-6 vials) ready for administration

Required Actions

- Administer 4-6 vials of Crotalidae Polyvalent Immune Fab (Ovine) Antivenom (CroFab) over 1 hour

Branch Point

- **IF PATIENT IS ASKED ABOUT ALLERGIES**, patient reports none, and antivenom should be started.
- **IF PATIENT IS NOT ASKED ABOUT ALLERGIES**, patient will experience hypotension and will report that she “doesn’t feel right” with the start of antivenom administration. **ANTIVENOM SHOULD BE PAUSED IF THIS HAPPENS; PATIENT’S SYMPTOMS WILL RECOVER.**

CASE CONTINUATION

Required Actions

- Order repeat labs to be drawn after completion of infusion
- Admit to inpatient bed (ICU – **OR** – intermediate status – **OR** – floor bed based on institutional policy)

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STIMULUS INVENTORY

- #1 Complete blood count
- #2 Basic metabolic panel
- #3 Urinalysis
- #4 Liver function tests
- #5 Venous blood gas
- #6 Troponin
- #7 Toxicology / Urine drug screen
- #8 Coagulation studies
- #9 Point-of-care serum glucose
- #10 ECG
- #11 Hand x-ray
- #12 Snake

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LAB DATA & IMAGING RESULTS

Stimulus #1	
Complete Blood Count (CBC)	
WBC	16,500/mm ³
Hemoglobin	13.2 g/dL
Hematocrit	40%
Platelets	23,000/mm ³
Differential	
PMNLs / Bands	45% / 1%
Lymphocytes	55%
Monocytes	2%
Eosinophils	1%

Stimulus #2	
Basic Metabolic Profile (BMP)	
Sodium	145mEq/L
Potassium	3.6mEq/L
Chloride	109 mEq/L
Bicarbonate	18 mEq/L
Glucose	82 mg/dL
BUN	17 mg/dL
Creatinine	1.0 mg/dL

Stimulus #3	
Urinalysis	
Color	Yellow
Specific gravity	1.017
Glucose	Negative
Protein	Negative
Ketones	Negative
Leuk. Esterase	Negative
Nitrites	Negative
WBC	1/hpf
RBC	0/hpf

Stimulus #4	
Liver Function Tests	
AST	49 U/L
ALT	32 U/L
Alk Phos	110 U/L
T. Bilirubin	1.2 mg/dL
D. Bilirubin	0.2 mg/dL
Albumin	4.3 mg/dL

Stimulus #5	
Venous Blood Gas	
pH	7.39
pCO ₂	19 mm Hg
pO ₂	39 mm Hg
HCO ₃	14 mEq/L
SaO ₂	100% (FiO ₂ =0.21)

Stimulus #6	
Troponin	
Value	< 0.02 ng.mL

Stimulus #7	
Toxicology	
Salicylate	Undetectable
Acetaminophen	Undetectable
Ethanol	Undetectable
Urine drug screen	
Amphetamines	Negative
Benzodiazepines	Negative
Cocaine	Negative
Opiates	Negative
TCA's	Negative
THC	Negative

Stimulus #8	
Coagulation Studies	
Fibrinogen	< 60 mg/dL
PTT	59.8 seconds

Stimulus #9	
Point-of-care serum glucose	
80 mg/dL	

Stimulus #10	
ECG	
Sinus tachycardia	

Stimulus #11	
Hand x-ray	
Soft tissue edema. No air, FB, fracture or dislocation	

Stimulus #12	
Snake	
Rattlesnake	

Stimulus #1**Complete Blood Count (CBC)**

WBC	16,500/mm ³
Hemoglobin	13.2 g/dL
Hematocrit	40%
Platelets	23,000/mm ³
Differential	
PMNLs / Bands	45% / 1%
Lymphocytes	55%
Monocytes	2%
Eosinophils	1%

Stimulus #2**Basic Metabolic Profile (BMP)**

Sodium	145mEq/L
Potassium	3.6mEq/L
Chloride	109 mEq/L
Bicarbonate	18 mEq/L
Glucose	82 mg/dL
BUN	17 mg/dL
Creatinine	1.0 mg/dL

Stimulus #3**Urinalysis**

Color	Yellow
Specific gravity	1.017
Glucose	Negative
Protein	Negative
Ketones	Negative
Leuk. Esterase	Negative
Nitrites	Negative
WBC	1/hpf
RBC	0/hpf

Stimulus #4**Liver Function Tests**

AST	49 U/L
ALT	32 U/L
Alk Phos	110 U/L
T. Bilirubin	1.2 mg/dL
D. Bilirubin	0.2 mg/dL
Albumin	4.3 mg/dL

Stimulus #5**Venous Blood Gas**

pH	7.39
pCO ₂	19 mm Hg
pO ₂	39 mm Hg
HCO ₃	14 mEq/L
SaO ₂	100% (FiO ₂ =0.21)

Stimulus #6

Troponin

Value	< 0.02 ng.mL
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Stimulus #7**Toxicology**

Salicylate	Undetectable
Acetaminophen	Undetectable
Ethanol	Undetectable

Urine drug screen

Amphetamines	Negative
Benzodiazepines	Negative
Cocaine	Negative
Opiates	Negative
TCAs	Negative
THC	Negative

Stimulus #8

Coagulation Studies

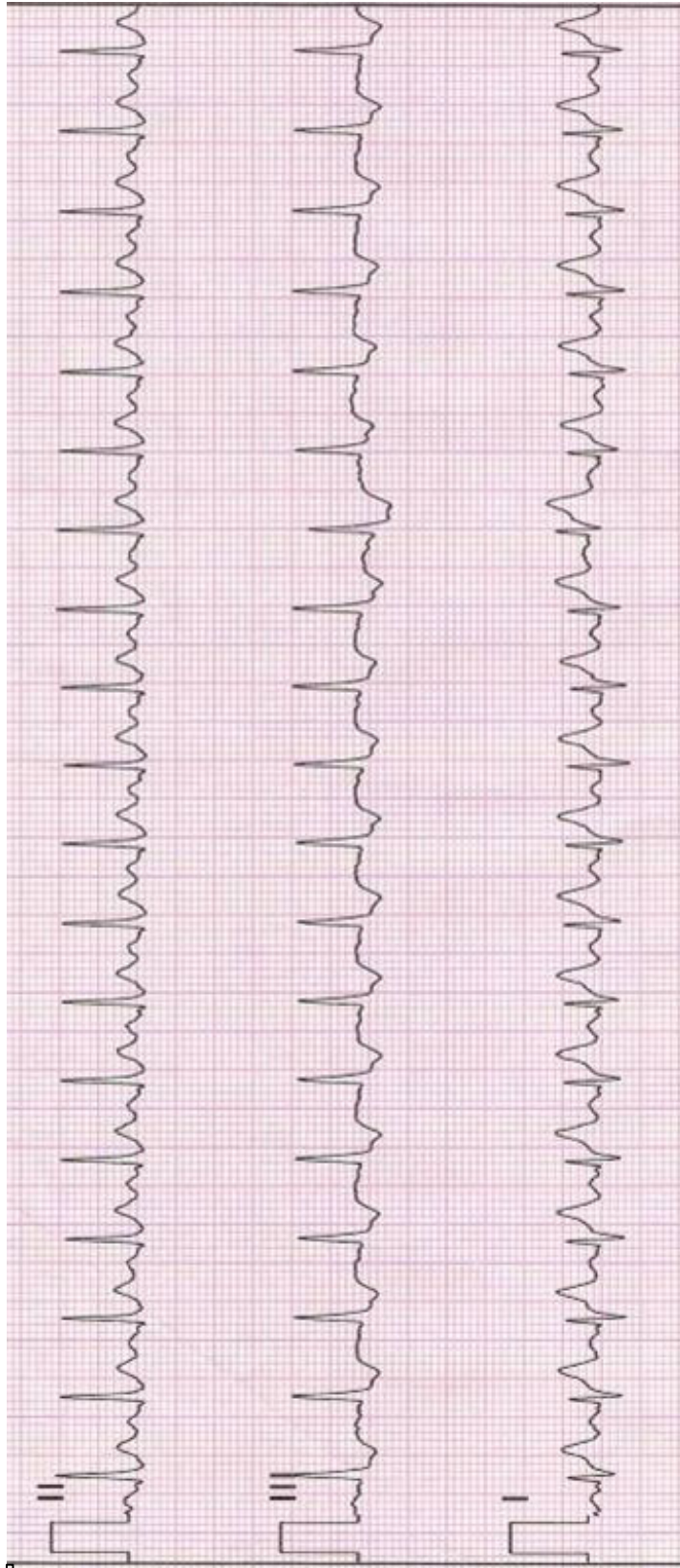
Fibrinogen	< 60 mg/dL
PTT	59.8 seconds

Stimulus #9

Serum glucose

80 mg/dL

Stimulus #10



Stimulus #11



Debriefing Materials - Rattlesnake Envenomation

Sources of Exposure:

- Common venomous snakes native to North America include the *crotalus* species Western Diamondback, Eastern Diamondback, and the Mojave

Pathophysiology:

- The pathophysiology of rattlesnake venom is complex and incompletely understood
- It has procoagulant and anticoagulant effects
- Some of the anticoagulant effects can be explained by the presence of thrombin-like enzyme in the snake venom which causes incomplete cross-linking of fibrin strands and fibrinogenolysis
- Rattlesnake venom is removed through the lymph system, thus pain and tenderness in regional lymph nodes is to be expected

Organ System Effects:

- Hematologic:
 - Rattlesnake venom can cause a significant decrease in platelets and fibrinogen along with an increase in PT, PTT, and INR
 - Envenomations can also produce a drop in hemoglobin and hematocrit secondary to extensive extravasation and bruising
 - Laboratory results look like DIC, but is not true DIC
- Integumentary:
 - Edema, ecchymosis, pain, blisters, blebs, and bullae are all common signs of a rattlesnake envenomation.
- Cardiovascular:
 - Tachycardia, Hypotension
- Nervous:
 - Paresthesias, metallic taste in the mouth, circumoral numbness
- Gastrointestinal:
 - Nausea, vomiting, diarrhea

Diagnostic Testing:

- D-dimer (only once upon presentation) – an elevated D-dimer in isolation is suggestive of envenomation and supports continued observation time of suspected dry bites
- Marking of leading edge of swelling/induration (not circumference) along with time of measurement
- X-ray of bitten extremity to rule-out retained fang
- The following labs should be done:
 - Upon presentation
 - 1 hour after loading dose of antivenom
 - 1 hour prior to each maintenance dose of antivenom
 - Before discharging home
- Complete Blood Count
 - Looking specifically at platelets, hemoglobin, and hematocrit
- Fibrinogen
- Coagulation
 - PT/INR, PTT

Treatment:

- Antivenom! Antivenom! Antivenom!
 - 4-6 vials of Crotalidae Polyvalent Immune Fab (Ovine) as loading dose
 - No good data on when to use 4 or 6 vials – When in doubt, give 6
 - Maintenance dose of 2 vials Q6H for 3 doses once control has been established (i.e., 1st dose is 6 hours after initial control achieved)
 - Control is defined as less than an inch an hour of progressive swelling along with platelets, fibrinogen, and coags all showing signs of improvement (if affected at all), and resolution of systemic/neurologic symptoms
 - Lab cutoffs to define coagulopathy are Fibrinogen < 150 mg/dL, Platelets < 150,000 /mm³, and INR > 1.5
 - If control has been lost, start over with another loading dose and repeat process
 - Contact the Poison Control Center
- Elevate the extremity above the level of the heart
- Update tetanus if needed
- AVOID:
 - Ice
 - NSAIDS/ASA/anticoagulants
 - Tourniquets
 - Prophylactic antibiotics
 - Prophylactic fasciotomy
 - Platelets
- There is some controversy regarding the optimal time of removal of tourniquets. Some experts recommend starting antivenom infusion prior to removal or at least having IV access, especially if it has been in place for an hour or more. Others simply recommend removal as soon as a tourniquet is recognized.

Consultations:

- Consult the regional poison center or a local medical toxicologist for additional information and patient care recommendations.
- Consult PT/OT for hand/walking exercises

Disposition:

- Patients with no immediate signs or symptoms of envenomation should be observed for 8-12 hours before being considered for discharge and repeat labs collected q 6 hours
 - Remember, envenomations can manifest as all local injury with no coagulopathy or as all coagulopathy with very minimal local injury. An exclusion of one does not equal a dry bite
- Patients will need to be admitted to a setting with frequent nursing care for wound evaluation and monitoring for progression such as an ICU
- After discharge, patients will still be at risk for coagulopathy regardless if he/she had one during the course of hospitalization
 - Advise patients to avoid surgeries and high-risk activities/contact sports until all labs in outpatient series are completed and confirmed normal by the Poison Control Center or Medical Toxicologist
 - They should follow-up with a PCP for repeat labs at 2-3, 5-7, and 10-14 days post discharge to assess for coagulopathy

Take-Home Points:

- Rattlesnake envenomations can present as all local, all coagulopathic, all systemic, or a combination of symptoms
- Baseline labs should include
 - Platelets
 - Fibrinogen
 - PT/INR
 - Hemoglobin/Hematocrit
 - D-dimer (only once)
- Standard treatment calls for 4-6 vials over 1 hour as a loading dose followed by 2 vials every 6 hours for 3 doses once initial control is achieved
- Control is defined as progression of swelling less than an inch an hour along with coag studies improving (if affected at all)
 - After antivenom, platelets tend to rebound quickly, while fibrinogen tends to take longer to recover. If platelets have recovered, low or undetectable fibrinogen by itself may not require a second loading dose. Contact the Poison Control Center for guidance.
 - Swelling is broken down into two categories: progressive and redistribution
 - Progressive swelling is proximal swelling that has a firm, indurated, woody edge. This is an indication of the venom effect spreading. Circumferential measurements are not recommended.
 - Redistribution swelling is swelling that is soft and has no firm edge. This is a normal process of recovery and is expected.
 - It can be extremely difficult at times to distinguish between the two – contact Poison Control Center for guidance.
- Labs should be repeated 1 hour after the loading dose, 1 hour before each maintenance dose, and after the final maintenance dose before discharge
- Avoid ice, steroids, and anticoagulants as these can worsen the effects of envenomation
- If possible it is important to keep envenomed limb elevated above the heart to promote fluid redistribution
- Current FDA approved rattlesnake antivenom is pharmacokinetically mismatched against rattlesnake venom
 - The antivenom is a small molecule that is readily excreted by the kidneys, while the venom is a large molecule that may deposit itself into tissues and last much longer than the antivenom
 - This is a possible explanation as to why patients develop a delayed or recurrent coagulopathy after discharge
- Before giving blood products, consider the underlying cause of the coagulopathy, the venom, and treat accordingly by giving antivenom
 - If blood products are still needed, give them with antivenom
 - Otherwise, blood products administered will just be consumed by the venom still present in the patient
- Patients are still at risk for venom effects for weeks after discharge even if he/she had a very normal hospital course
- The Poison Control Center will continue to follow the patient and work with his/her provider for a series of outpatient labs.
- Always call the Poison Control Center whenever there is a rattlesnake bite. Each exposure adds to our database of knowledge so that we can continue to treat these in the most efficient way possible

References:

1. CroFab® package insert. West Conshohocken (PA): BTG International Inc.; 2000.
2. Lavonas EJ1, Ruha AM, Banner W, Bebart V, Bernstein JN, Bush SP, Kerns WP 2nd, Richardson WH, Seifert SA, Tanen DA, Curry SC, Dart RC; Rocky Mountain Poison and Drug Center, Denver Health and Hospital Authority. Unified treatment algorithm for the management of crotaline snakebite in the United States: results of an evidence-informed consensus workshop. *BMC Emerg Med.* 2011 Feb 3;11:2. doi: 10.1186/1471-227X-11-2.
3. Keating GM. Crotalidae polyvalent immune Fab: in patients with North American crotaline envenomation. *BioDrugs.* 2011 Apr 1;25(2):69-76. doi: 10.2165/11207250-000000000-00000.