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Approach to the diagnosis and management of snakebite envenomation in South Africa in humans: Layperson aspects and the role of emergency medical services

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Snakebites occur in the community, not in the Emergency Unit. As such it is important to understand the first-aid concepts and pre-hospital emergency care aspects of this neglected disease. This article will highlight the concepts for emergency care within the context of the current pre-hospital arena and in light of the recent South African Snakebite Symposium consensus meeting held in July 2022, where wilderness rescue, emergency medical services and other medical participants agreed through evidence review and consensus debate on the current best approaches to care of the snakebite victim outside the hospital environment.

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South Africa (SA) has over 170 species of snakes, but of these, around 20 comprise the 'dangerous and deadly' category. Regarding management of snake envenomation, the World Health Organization (WHO) Africa document is now more than 10 years old, covers aspects of management that are not specific to SA and mentions treatment options that may no longer be accepted or available.[1]

This paper focuses on the human treatment guidelines to be used by the layperson when confronted with a snakebite and the role of the emergency medical services in emergency care and transport of the snakebite victim. What we mean by the layperson is the non-professional 'first-aider' level.

Snakebites occur in one of two distinct scenarios, which are categorised as legitimate and illegitimate: so-called legitimate bites occur where a person unintentionally and unknowingly provokes a venomous snake (e.g. stepping on a snake while out walking), while illegitimate bites occur when someone sees a snake and then tries to catch, kill or otherwise interact with it and is bitten. The latter bites are typically seen in snake owners, breeders or snake-removers who are intentionally interacting with often the more venomous species.[2]

Most of what is recommended in the care of snakebite is largely expert opinion based on retrospective data, with little or no randomised or prospective studies available on the treatment of snake envenomation in this country. The article aims to provide the current best evidence and best practice information for the benefit of every SA citizen. The attached flip-chart addressing the level of care aims to provide a pocket-friendly resource for the layperson and the emergency medical services (EMS) practitioner.

Layperson role

The layperson who assists a snakebite victim is encouraged to move the victim to safety away from the snake. The victim should be moved as minimally as possible, washing away excess venom and marking the bite-site, but not engaging in the use of cutting, sucking, electrocuting or amputating the wounded area. Tourniquets are actively discouraged, with the designated exceptions of cape cobra or black mamba bites in cases where more than a 90-minute delay to emergency care is expected (wilderness environment). These specific bites should rather have tight pressure bandages applied over a broad area proximal to the bite site (e.g. wrist to elbow for a hand bite), or commercial-type tourniquets applied, rather than improvised tourniquets, although these are not strongly advocated.

A list of whom to contact for advice and evacuation is supplied (emergency numbers) on the flip-chart (Fig. 1).[3] Flow-charts provide emergency life-saving support advice (breathing support and cardiopulmonary resuscitation) and basic first aid using the syndromic approach, rather than reliance on snake identification. If it is possible to photograph the snake, this is advised, rather than risking an illegitimate bite while trying to catch the snake. From a wound management perspective, pressure bandaging and immobilisation for suspected neurotoxic bites and limb mobilisation for suspected cytotoxic bites are detailed, in line with newer evidence showing less cytotoxicity if mobility is maintained.

To ensure that laypersons can quickly access and follow a safe care pathway, an 8-page share-ware flipchart was designed for widespread public distribution, partially illustrated in Fig. 1.[3]

Emergency medical service role

While the main role of the EMS is patient access, stabilisation, extrication and urgent evacuation to an appropriate definitive care facility, there are aspects of the EMS clinical practice guidelines (CPGs) that are affected by the envenomation syndromes, and as such, it is important to highlight to EMS the essential adjustments to be considered when treatment of snake envenomation is undertaken.[4]

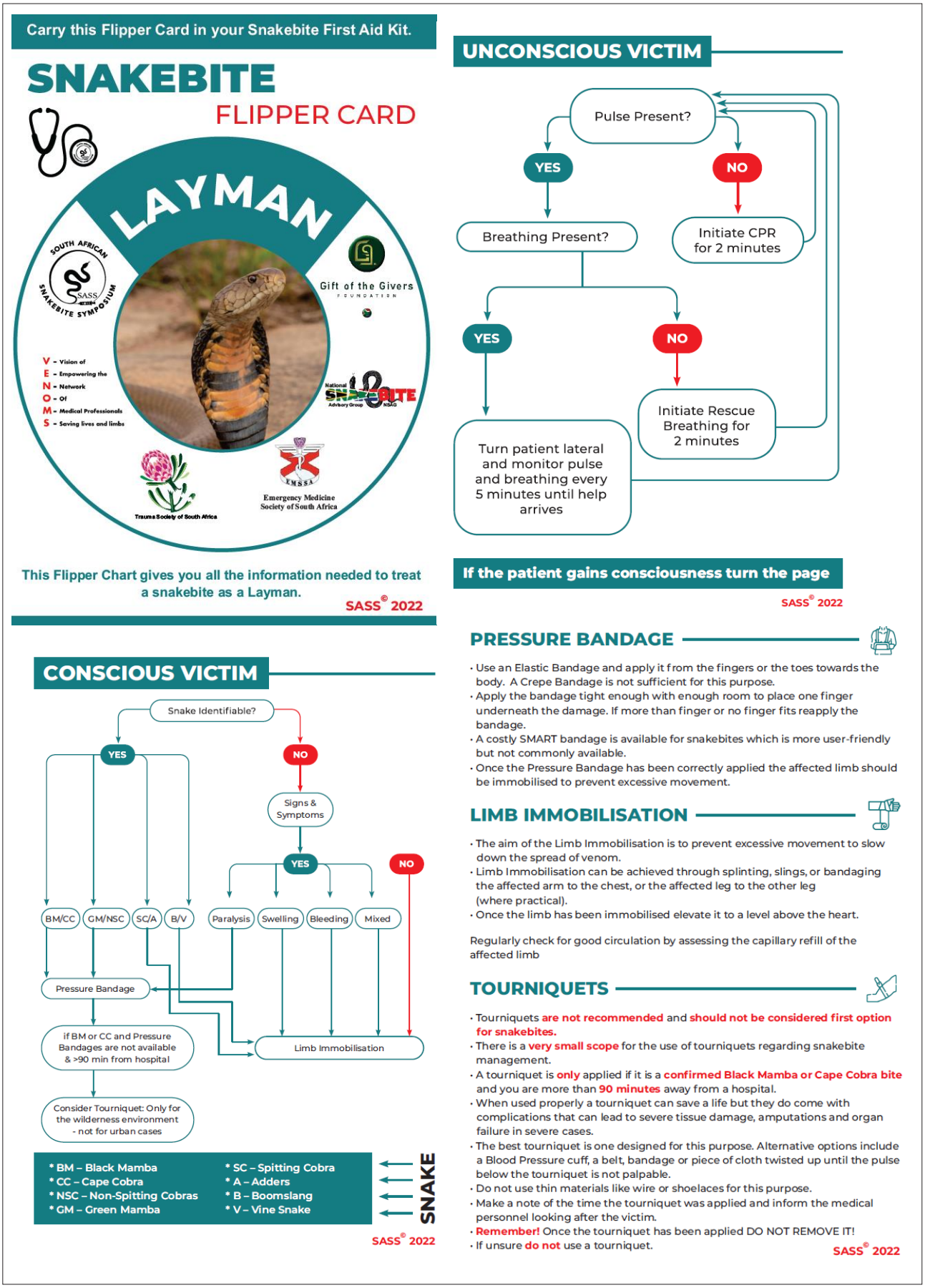


Fig. 1. Layperson flipchart cover and flowcharts for management.

1. Recognise neurotoxicity as emergency
2. Prepare for airway control and ventilation
3. Supplement oxygen via nasal prongs and non-rebreather mask for $Sp0_2$<94%
4. If hypoventilation/apnoea, start BVM ventilation with 0_2

Pre-intubation check (SOAP MEA)
1. Suction with yankauer catheter
2. Oxygen (mask, $NP0_2$, BVM ventilation)
3. Airway equipment
   - Laryngoscopes with different size blades
   - ET tube (2 sizes)
   - Introducer and bougie (if available)
   - Supraglottic airway device
   - Surgical airway equipment
   - Stethoscope
   - Strapping/fixing material ready to secure endotrachaeal tube

4. Pharmacy
   - Running IV line
   - Medication sedation, neuromuscular blocker on standby
   - Emergency drugs (i.e. adrenaline, atropine)
   - Draw up drugs and keep in sequence of administration

5. Monitoring equipment – $Sp0_2$, BP, ECG, $ETCO_2$ – if available

6. Assign roles - Airway control (intubater), assistant, drug administrator, nurse runner

Drugs:

Rapid sequence intubation medication	
mg/kg 1 - 2 0.1 - 0.3	**Induction** Ketamine Etomidate
mg/kg 1 - 2 1 - 1.2	**Neuromuscular blocker** Suxamethonium – AVOID Rocuronium – only if needed

Is the patient optimised?
1. Positioning (rolled-up blanket under shoulders works well, 'sniffing morning air' position, C-spine protection should not be a major concern)
2. Difficult airway anticipated (examine patient neck mobility, Mallampati score, teeth concerns, cricothyroid area)
3. Pre-oxygenation
4. Circulation/haemodynamics optimised
5. Consider nasogastric suction

Intubation laryngoscopy 2 - 3 attempts
(consider different size blade or different size ET tube) → alternative airway
(LMA, LTA, iGel → surgical airway

Post intubation
1. Check correct position of tube (misting, $ETCO_2$ rising sats, equal air entry/rising chest bilateral) and note depth of tube
2. Blow up cuff and check pressure
3. Secure tube
4. Oropharyngeal airway
5. Ensure correct vent settings
6. Recheck vital signs
7. Ensure adequate sedation (ketamine 1 - 2 mg/kg/hour)

Basic ventilation settings

Baseline ventilator settings	
Mode	SIMV
Tidal volume	7 mL/kg
PIP	12 - 14 cm H_2O
PEEP	5
I:E	1:2
Rate	12 - 16 bpm (adults), 20 - 25 bpm (paediatrics), 25 bpm (neonates)

Notes
- In patients without comorbidities, a basic ventilation setup should be adequate for neurotoxic envenomation.
- Neurotoxicity may mimic brain death be careful to not make this diagnosis prematurely.
- Prolonged ventilation is often required especially in the absence of antivenom administration. Several cases have been recorded of patients requiring ventilation for more than a week.

Fig. 2. Emergency medical services airway and ventilation management algorithms. (BVM = bag-valve-mask; ET = endotrachaeal; BP = blood pressure; ECG = electrocardiogram; $ETCO_2$ = end-tidal carbon dioxide; IV = intravenous; NG = nasogastric; LMA = laryngeal mask airway; LTA = laryngeal tube airway; PIP = peak inspiratory pressure; PEEP = positive end-expiratory pressure; I:E = inspiratory to expiratory ratios; SIMV = synchronised intermittent mandatory ventilation.)

Aspects of scene safety, relevant historic information and the essential minimum vital signs are emphasised. Important physical examination aspects for documentation of bites and related physiology or pathology are listed. Removal of rings and other tight circumferential items is encouraged. The care provider is instructed to circle the site of the bite with a marking pen if visible, and record the time of bite on the skin. Progression of swelling from the first circle to the rest of the limb or affected area should be recorded at least every hour. The affected area should be elevated, if possible, at least to the level of the heart, and then rapid transfer to a hospital with access to monitoring and antivenom is imperative.

For care on the way to a receiving facility, management algorithms for airway control, breathing and hypotension are provided. For airway and breathing considerations, the risk of respiratory depression due to respiratory muscle paralysis is great in neurotoxic bites. Bag-valve-mask ventilations are advised for respiratory depression until intubation can be safely performed. Respiratory depression can be potentiated by opioids, by potentiating certain venom components, so ketamine is advised both for intubation and analgosedation in transit. Etomidate is a suitable alternative for induction. See Fig. 2 for a practical airway and ventilation management algorithm.

Since the majority of cases that require airway support and ventilation are neurotoxic bites that cause respiratory paralysis, it is advised to use no, or reduced-dose, paralytic agents and to avoid suxamethonium in this circumstance, with rocuronium as the paralytic of choice if any is used. Suxamethonium should be avoided since it has many overlapping effects accentuating those of the pre-synaptic venoms (fasciculins and dendrotoxins) of the black mamba and may lead to bradycardia or a prolonged paralysis.

With hypotensive patients the consensus group emphasises that the fluid therapy is not restrictive, but rather more in line with the 'surviving sepsis' values of *up to* 30 mL/kg using a balanced salt solution.[5] Should the patient still elicit signs of hypoperfusion, then adrenaline infusions are advised. Tranexamic acid (TXA) should not be given[6] (confirmed by Prof. David Warrel, WHO Expert antivenom group – personal communication).

For neurotoxic bites compression bandages only are advised in transit – this is to avoid the unnecessary use of the tourniquet, unless already in place, in which case this is left in place for safe removal at the receiving hospital, where a potential venom rush can be managed.[7] Since commercial tourniquets are included in the CPGs, inappropriate use should be discouraged. Adequate distal perfusion, however, takes priority over a tight bandage. All this information is summarised in an 8-page flipchart that is partially illustrated in Fig. 3.[8]

The flipcharts also illustrate the common venomous snakes and give a general idea of their distribution; however, this may vary, and snakes can be found outside the listed areas due to migration or captivity.

Conclusion

Laypersons and EMS providers are often the first contact that the snakebite victim has with any form of care-provider, and as such, it is better to know the basics and undertake these steps safely to ensure

ASSESSING THE SNAKEBITE

SCENE SIZE UP

- **SCENE SAFETY** - Ensure everyone is safe from a second snakebite.
- **C-A-B**
- **CYTOTOXIC BITES:**

Remove constricting rings / jewellery and clothing

MARK SWELLING - Circle the site of the bite with a pen if visible. Write the time of bite on the skin. Document progression of swelling from the first circle to the rest of the limb or affected area. The affected area should be **ELEVATED. RAPID** transfer to a hospital is imperative.

- **NEUROTOXIC BITES:**

PRESSURE BANDAGES - are **ONLY USED IN NEUROTOXIC BITES.** Ensure adequate circulation is present in the distal point of the limb if a pressure bandage is applied. **TOURNIQUETS** should **ONLY** be used when **A PRESSURE BANDAGE IS NOT** available in a **CONFIRMED BLACK MAMBA OR CAPE COBRA BITE** and if you are more than **90 MINUTES AWAY** from definitive care at a hospital. **DO NOT REMOVE** a tourniquet if it is in place **UNLESS** progressive swelling syndrome presents as per CPGs. If an improvised tourniquet is in place, replace it with a commercial tourniquet **ABOVE** the improvised one.

VITALS

- Heart Rate
- Temperature
- Blood Pressure
- HGT
- ETCO2
- Respiratory Rate
- Skin condition
- SpO2
- GCS
- ECG monitoring

PHYSICAL EXAMINATION

- Fang marks - absence of fang marks does not rule out snakebite
- Signs and Symptoms - Swelling, Paralysis, Bleeding, etc.
- Signs of Shock?

HISTORY

- SAMPLE
- Where on the body was the patient bit?
- How long has it been since the snakebite?
- Is there an identification/description of the snake?
- What activity was performed at the time of the bite?
- Has the patient sustained a snakebite before?

SNAKEBITE EMERGENCY CONTACT NUMBERS

National Poison Control Centre	086 155 5777	Mande Toubkin	082 820 7914
Prof A Engelbrecht	084 789 7364	Jason Seale	082 781 8498
Prof T Hardcastle	082 468 1615	Arno Naude	083 739 9303
Dr S Garach	082 495 0135	Mike Perry	083 448 8854
Dr C Bell	073 174 0199	Chris Hobkirk	082 372 3350
Dr V Lalloo	082 700 2732	Johan Marais	082 494 2039

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HYPOTENSION

Systolic BP <90mmHg with a bradycardia (<60bpm) → Fix underlying causes. Administer Oxygen if hypoxic and consider airway control if airway is unprotected. Autonomic dysfunction is common with neurotoxic bites → If pulse remain <60 bpm consider 0.5mg Atropine repeated every 5 minutes up to 3mg (adults dose). Consider adrenaline infusion if hypotension persists and patient non-responsive

Systolic BP <90mmHg with a normal pulse rate (60-100bpm) → Fluid Resuscitation 1000-2000ml fluid boluses (maximum 30ml/kg) as per SEPSIS-3 guideline (snakebite is not trauma) → Should the BP remain <90mmHg initiate adrenaline infusion. Titrate to effect

Adult Adrenaline Infusion Chart – No Syringe Driver

Prepare	Weight	Range (ml/hr)		
		Lowest	Mid	Highest
3x1mg/ml (1:1000) Adrenaline + 47ml 0.9% Normal Saline	2	0.2ml/hr	1ml/hr	2ml/hr
	4	0.4ml/hr	2ml/hr	4ml/hr
	6	0.6ml/hr	3ml/hr	6ml/hr
	8	0.8ml/hr	4ml/hr	8ml/hr
	10	1ml/hr	5ml/hr	10ml/hr
	20	2ml/hr	10ml/hr	20ml/hr
	25	2.5ml/hr	12.5ml/hr	25ml/hr
	30	3ml/hr	15ml/hr	30ml/hr
	35	3.5ml/hr	17.5ml/hr	35ml/hr
	40	4ml/hr	20ml/hr	40ml/hr
	45	4.5ml/hr	22.5ml/hr	45ml/hr
	50	5ml/hr	25ml/hr	50ml/hr
	55	5.5ml/hr	27.5ml/hr	55ml/hr
	60	6ml/hr	30ml/hr	60ml/hr
	65	6.5ml/hr	32.5ml/hr	65ml/hr
	70	7ml/hr	35ml/hr	70ml/hr
	75	7.5ml/hr	37.5ml/hr	75ml/hr
	80	8ml/hr	40ml/hr	80ml/hr
	85	8.5ml/hr	42.5ml/hr	85ml/hr
	90	9ml/hr	45ml/hr	90ml/hr
	95	9.5ml/hr	47.5ml/hr	95ml/hr
	100	10ml/hr	50ml/hr	100ml/hr
	110	11ml/hr	55ml/hr	110ml/hr
	120	12ml/hr	60ml/hr	120ml/hr

Adult Adrenaline Infusion Chart – No Syringe Driver

Prepare	Mix 2x 1mg (1:1000) Adrenaline + 198ml 0.9% Normal Saline in a 200ml drip with a 60 Dropper administration set. Titrate to effect		
Dosage (2-10ug/min) 2	2ug/min = 1drop every 5 seconds	5ug/min = 1 drop every 2 seconds	10ug/min = 1 drop every second

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Fig. 3. Emergency medical services treatment guidelines.

the patient arrives at the emergency department in a timely fashion with the best possible degree of resuscitation based on current best evidence.

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