Defining the need for surgical intervention following a snakebite still relies heavily on clinical assessment: The experience in Pietermaritzburg, South Africa

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Background. This audit of snakebites was undertaken to document our experience with snakebite in the western part of KwaZulu-Natal (KZN) Province, South Africa (SA).
Objective. To document our experience with snakebite in the western part of KZN, and to interrogate the data on patients who required some form of surgical intervention.
Methods. A retrospective study was undertaken at the Pietermaritzburg Metropolitan Trauma Service, Pietermaritzburg, SA. The Hybrid Electronic Medical Registry was reviewed for the 5-year period January 2012 - December 2016. All patients admitted to the service for management of snakebite were included.
Results. The offending snake is rarely identified, and the syndromic approach is now the mainstay of management. Most envenomations seen during the study period were cytotoxic, presenting with painful progressive swelling (PPS). We did not see any purely neurotoxic or haemotoxic envenomations. Antivenom is required for a subset of patients. The indications are essentially PPS that increases by >15 cm over an hour, PPS up to the elbow or knee after 4 hours, PPS of the whole limb after 8 hours, threatened airway, shortness of breath, associated clotting abnormalities and compartment syndrome. If no symptoms have manifested within 1 hour of a snakebite, clinically significant envenomation is unlikely to have occurred. Antivenom is associated with a high rate of anaphylaxis and should only be administered when absolutely indicated, preferably in a high-care setting under continuous monitoring. The need for surgery is less well defined. Urgent surgery is indicated for compartment syndrome of the limb, which is a potentially life- and limb-threatening condition. Its diagnosis is usually made clinically, but this is difficult in snakebites. Morbidity and cost increase dramatically once fasciotomy is required, as evidenced by much longer hospital stay. There is frequently a degree of cross-over between cytotoxicity and haemotoxicity in envenomations that require fasciotomy, which means that fasciotomy may result in catastrophic bleeding and should be preceded by the administration of antivenom, especially in patients with a low platelet count or a high international normalised ratio. Physiological and biochemical markers are unhelpful in assessing the need for fasciotomy. Objective methods include measurement of compartment pressures and ultrasound.
Conclusion. The syndromic management of snakebite is effective and safe. There is a high incidence of anaphylactic reactions to antivenom, and its administration must be closely supervised. In our area we overwhelmingly see cytotoxic snakebites with PPS. Surgery is often needed, and we need to refine our algorithms in terms of deciding on surgery.

S Afr Med J 2017;107(12):1082-1085. DOI:10.7196/SAMJ.2017.v107i12.12628

The management of snakebite injuries remains controversial and a source of endless fascination for surgeons. Treatment can seldom be based on the identity of the snake, as it is very unlikely that the offending reptile can be captured and accurately identified. For this reason, the current approach is a syndromic one, popularised by Blaylock[1] around the turn of the millennium and based on the clinical syndrome seen and the response to treatment. There are essentially three syndromes: painful progressive swelling (PPS), progressive weakness, and bleeding.[1] We have tended to follow this approach to the management of snakebite over the past 10 years at our institution in the western part of KwaZulu-Natal (KZN) Province, South Africa (SA). There is still an area of controversy surrounding the need for surgical intervention. Most patients will respond to non-operative care, but a subset will require surgery as part of their management.

The syndromic approach to management of snakebite recognises the fact that it is usually impossible to adequately identify the type of snake that has bitten the patient. The three recognisable clinical syndromes of PPS, progressive weakness and bleeding[1] correspond to the three venom types, namely cytotoxic, neurotoxic, and haemotoxic. If one of these syndromes has not manifested within 1 hour of a snakebite, clinically significant envenomation is unlikely to have occurred.[2] According to Blaylock,[1] the therapeutic triad of elevation, intravenous fluids and analgesia is the mainstay of managing

snakebites. Elevation is analgesic and diminishes venous swelling, and intravenous fluids replace the intravascular fluid that has extravasated into the tissues.[1] In addition to these basic supportive interventions, antivenom and surgery are two other interventions that need to be used selectively. Antivenom is needed for a subset of patients. In broad terms the indications include complications of PPS, rapid respiratory deterioration following neurotoxic envenomation, or uncontrolled bleeding.[1] Surgery is indicated mainly for compartment syndrome of the limbs, and debridement following tissue necrosis or secondary sepsis.[3]

Objective

This audit was undertaken to document our experience with snakebite in the western part of KZN, and to interrogate the data on patients who required some form of surgical intervention.

Methods

Clinical setting

This was a retrospective study undertaken at the Pietermaritzburg Metropolitan Trauma Service (PMTS) in Pietermaritzburg, the capital of KZN. The Hybrid Electronic Medical Registry (HEMR) was reviewed for the 5-year period January 2012 - December 2016. The PMTS provides definitive trauma care to the city of Pietermaritzburg. It is one of the largest academic trauma centres in KZN and also serves as the referral centre for 19 rural hospitals in the province, with a total catchment population of over three million.

The study

All patients admitted to our service for management of snakebite were included in this study. Basic demographic data, mechanism of injury and admission physiology were reviewed, as were all operative records. Details of the site of the snakebite, the type of syndrome, the clinical progression of the syndrome, the need for antivenom and need for operative management were recorded. The outcome of each operative intervention was documented. All in-hospital morbidities were reviewed.

The Zululand Scoring System (ZSS)

Wood *et al.*[4] have proposed a scoring system in snakebites to attempt to predict the likelihood of an active treatment intervention (ATI). ATI includes the administration of antivenom and any surgery (including debridements, amputations or fasciotomies). The scoring system allocates a point for each of age <14 years, admission >7 hours, white cell count >10 × 10^9/L, international normalised ratio (INR) >1.2, platelet count <92 × 10^9/L, and haemoglobin concentration <7.4 g/dL. Patients scoring ≥4 are predicted to require an ATI. We set out to use data from the HEMR to see whether the ZSS could be validated.

Ethics approval

Ethics approval for this study and for maintenance of the registry was obtained from the Biomedical Research Ethics Committee of the University of KwaZulu-Natal (ref. nos BE 207/09 and BCA 221/13).

Results

A total of 222 patients were admitted following a snakebite during the period under review. The male/female ratio was 1.36:1. The average age was 21.4 years. Just under half of the patients (47.8%) were <12 years of age, and just under a third (29.2%) were between 12 and 35 years old. The snakebite was witnessed in 202 cases (91.0%), but the snake was positively identified in only 14 cases (6.3%). The sites of the bites are listed in Table 1. A tourniquet was applied in 8 cases (3.6%). These were applied at the base hospital. The bites were venomous in 200 cases (90.1%) and either non-venomous or a 'dry bite' in the remainder. In 99.1% of cases there was a single bite. Of the bites that were venomous, 187 (93.5%) were cytotoxic and 13 (6.5%) were cytotoxic and haemotoxic. There were no pure haemotoxic or neurotoxic bites. Eighteen patients (8.1%) required intensive care unit (ICU) or high-care admission. In 8 cases (44.4%) this was because of complications of the envenomation, and in 10 cases (55.6%) because of anaphylaxis from antivenom administration.

Table 1. Sites of the snakebites

Area bitten	Patients, %
Toes	4.1
Foot	47.8
Leg	19.4
Thigh	1.4
Fingers	3.6
Hand	13.5
Forearm	5.4
Upper arm	1.4
Head and neck	2.3
Trunk	1.4

Antivenom

Antivenom was required in 28 patients (12.6%). Compared with older patients, more patients aged <20 years received antivenom (58.6%). The rate of anaphylaxis was 42.9%. Children (<12 years) were most likely to develop anaphylaxis (58.3%). We did not have any mortality as a result of anaphylaxis, although 13 patients (46.4%) who received antivenom required ICU or high-care admission. Four of these patients required ventilation, 1 as a result of airway compromise after cytotoxic envenomation, and 3 as a consequence of anaphylaxis. Twelve patients (42.9%) who received antivenom required fasciotomy. The average length of stay for a patient who received antivenom was 7.5 days, compared with 2.8 days for those who had simple management.

Surgery

An operation was required in 33 patients (14.9%). Fasciotomy was performed in 14 patients (6.3%). The male/female ratio of patients who required fasciotomy was 1.56:1. A large proportion of patients requiring fasciotomy (50.0%) were between the ages of 13 and 35 years. Fasciotomies were performed equally on the upper and lower limbs, and equally on patients over and under 20 years of age. A total of 6 patients (42.9%) who underwent fasciotomy required high-care or ICU admission postoperatively. Over two-thirds (78.6%) of patients who required fasciotomy needed follow-up surgery for debridement, grafting or closure. The remainder healed by secondary intention, were grafted at base or were lost to follow-up. The average length of hospital stay for patients who received fasciotomy was 13.1 days. This is 10 days longer than the average hospital stay for patients with snakebite who received simple management. Other types of surgery included 16 debridements (7.2%), 12 split-skin grafts (5.4%), and 3 incision and drainages (1.4%). One amputation and one tendon repair were required.

Complications

The following complications were recorded: compartment syndrome 5.9%, acute kidney injury 2.7% and respiratory distress 2.3%. One patient had iatrogenic tendon injury during fasciotomy.

The Zululand Scoring System

A total of 44 of our patients required an ATI. Of these, 15 had scores of ≥4 points according to Wood *et al.*'s[4] ZSS (therefore predicting the need for ATI), which gives a positive predictive value of only 34.1%. Of the remaining patients (who did not require an ATI), 78 had sufficient data for a score to be calculated and of these 17 scored ≥4 points, providing a negative predictive value of 78.2%.

Discussion

The management of snakebite depends on the type of envenomation. However, the snake is very seldom identified and clinicians have to manage the bite according to a syndromic approach popularised by Blaylock from Eshowe Hospital in KZN. The most common syndrome has been reported as PPS from cytotoxic venom, most usually due to a bite from a puff adder, rinkhals or Mozambique spitting cobra,[1,5] which is very much in keeping with our findings. We did not manage any purely neurotoxic or haemotoxic bites. This contrasts with reports from our sister institution in Zululand,[5] reflecting the fact that the distribution of the two most notorious neurotoxic snakes, the black and green mambas, is largely in the coastal regions of KZN. The incidence of black mamba bites may in fact be under-reported, as these cases may not reach hospital. The surgical burden in Zululand is lower than in Pietermaritzburg.[5] Purely haemotoxic bites are rare because of the timid nature of the two haemotoxic snakes, the boomslang and vine snake (twig snake). The variation of the distribution of poisonous snakes in KZN is shown in Tables 2 and 3.

Antivenom is needed for a subset of patients. There are two major types of antivenom available, namely polyvalent and monovalent, produced by South African Vaccine Producers (SAVP). Polyvalent antivenom is available as an emergency stock item in most hospitals. A list of snakes that polyvalent antivenom is effective against is provided in Table 4. Monovalent antivenom is specific to the boomslang and must be ordered specifically from SAVP. A list of links and contact details is provided in Table 5. According to Blaylock,[1] the indications for antivenom in patients with PPS, our most commonly encountered scenario, include PPS that increases by >15 cm over an hour, PPS up to the elbow or knee 4 hours after envenomation, PPS of the whole limb after 8 hours, threatened airway, shortness of breath, associated clotting abnormalities and compartment syndrome. The indications for antivenom administration are listed in Table 6. The administration of antivenom is associated with a high rate of anaphylaxis.[5] Our rate of anaphylaxis was 42.9%, which is very much in keeping with reports by other local authors such as Wood *et al.*,[5] who had a rate of anaphylaxis of 23% (up to 43% in the 10 - 20-year age group). Antivenom must be administered in a high-care setting under continuous monitoring. We follow Wood *et al.*'s[5] recommendation to administer a dose of intramuscular adrenaline prior to antivenom administration. Although we had no deaths associated with anaphylaxis, just under half of the patients (46.4%) who received antivenom required ICU or high-care admission. More patients aged <20 years than older patients received antivenom. This is in keeping with Wood *et al.*'s[5] findings. These authors felt that the smaller size of the child in conjunction with equal envenomation from a bite meant that children were more likely to require antivenom than adults.[5] Children (<12 years) were more likely to develop anaphylaxis (58.3%), which is also in keeping with Wood *et al.*'s[5] findings. The protocol for antivenom administration is set out in Table 7.

The need for surgery is less well defined. Urgent surgery is required to manage a compartment syndrome of the limb, which is a potentially life- and limb-threatening condition traditionally diagnosed clinically by a tense and swollen limb with decreased perfusion.[3] This diagnosis is difficult, as a snake envenomation often mimics a compartment syndrome.[3] This is because the majority of cases are exquisitely tender and have 'pain on passive stretch' despite the absence of a true compartment syndrome. More reliable signs are a tense compartment with distal loss of sensation. Loss of distal pulse is a late sign. The situation in snakebite is complicated by the fact that the swelling may be confined to the subcutaneous fat and skin, not truly reflecting a compartment syndrome of the deep compartments.[6] Morbidity and cost increase dramatically once

Table 2. Poisonous snakes most commonly found in Zululand

Puff adder (*Bitis arietans*)
Night adder (*Causinae rhombeatus*)
Gaboon viper (*Bitis gabonica*)
Mozambique spitting cobra (*Naja mossambica*)
Rinkhals (*Hemachatus haemachatus*)
Zebra, western barred, or black spitting cobra (*Naja nigricincta*)
Forest or white-lipped cobra (*Naja melanoleuca*)
Snouted or banded Egyptian cobra (*Naja annulifera*)
Black mamba (*Dendroaspis polylepis*)
Green mamba (*Dendroaspis angusticeps*)
Vine or twig snake (*Thelotornis* species)
Boomslang (*Dispholidus typus*)

Table 3. Poisonous snakes most commonly found in the Pietermaritzburg area

Night adder (*Causinae rhombeatus*)
Puff adder (*Bitis arietans*)
Rinkhals (*Hemachatus haemachatus*)
Black mamba (*Dendroaspis polylepis*)*
Boomslang (*Dispholidus typus*)

*Less common than in the Zululand area.

Table 4. Envenomations for which polyvalent antivenom is effective

Puff adder (*Bitis arietans*)
Gaboon adder (*Bitis gabonica*)
Rinkhals (*Haemachatus haemachatus*)
Green mamba (*Dendroaspis angusticeps*)
Black mamba (*Dendroaspis polylepsis*)
Jameson's mamba (*Dendroaspis jamesoni*)
Cape cobra (*Naja nivea*)
Forest cobra (*Naja melanoleuca*)
Snouted (Egyptian) cobra (*Naja annulifera*)
Mozambique spitting cobra (*Naja mossambica*)

Table 5. South African Vaccine Producers contact details

Business hours	011 386 6063/2
After-hours emergency	011 386 6000
Fax	011 386 6016
E-mail	megans@savp.co.za cillaf@savp.co.za
Physical address	SAVP, Modderfontein Road, Sandringham, Johannesburg, South Africa
Postal address	PO Box 28999, Sandringham, Johannesburg, 2131

Table 6. Indications for antivenom administration[1]

Cytotoxic (PPS)	Neurotoxic (progressive weakness)	Haemotoxic (bleeding)
Swelling extending at 15 cm or more for 1 hour	Pins and needles, profuse sweating, and excessive salivation (or metallic taste) after mamba envenomation	Fang punctures do not stop bleeding and/or severe headaches, dizziness, fainting or convulsions
Swelling to the elbow or knee by 3 - 4 hours		
Swelling of a whole limb within 8 hours		
Swelling threatening the airway	Shortness of breath due to weakness in the absence of PPS	Active systemic bleeding (not bruising of the bitten limb alone)
Associated unexplained shortness of breath		
Associated abnormality of blood clotting (or prior to fasciotomy)	Inability to swallow saliva	Non-clotting blood after 20 minutes in an undisturbed, new, dry, clean test tube. Use blood from a healthy person as a control
Compartment syndrome or compressed major blood vessel	Generalised weakness in the presence of PPS or generalised muscle pain	Significant laboratory evidence of a blood clotting abnormality

PPS = painful progressive swelling.

Table 7. Protocol for antivenom administration[5]

Discuss with emergency medicine or surgery consultant prior to administration
Doctor with airway skills and appropriate drugs and equipment for urgent intubation and ventilation on standby
Facemask oxygen and two large-bore intravenous lines
Continuous pulse, blood pressure, and oxygen saturation monitoring
Resuscitation trolley and defibrillator on standby
Intramuscular or subcutaneous adrenaline 0.3 - 0.5 mg (0.01 mg/kg in children) prior to antivenom administration (hydrocortisone and promethazine are no longer given routinely)
Polyvalent antivenom 80 mL over 15 minutes (a repeat dose may be given if symptoms continue to progress in 1 - 2 hours)

fasciotomy is required, as evidenced by the much longer hospital stay. This highlights the importance of not performing fasciotomies unnecessarily. While our fasciotomy rate may be appropriate for a referral hospital, it must be kept in mind that some fasciotomies may have been performed unnecessarily and that clinical assessment alone, considering all its limitations in snakebites, may not be sufficient in deciding on the need for fasciotomy. Physiological and biochemical markers are unhelpful in assessing the need for fasciotomy. Objective methods include measuring of compartment pressures and ultrasound.[6] Measuring of compartment pressures is a painful, invasive and cumbersome technique. Wood *et al.*[4] have advocated the use of ultrasound as a painless and non-invasive technique of diagnosing compartment syndrome in snakebites. In Wood *et al.*'s[6] study of ultrasound findings in 42 patients with cytotoxic snakebites, it was found that swelling was most commonly confined to the subcutaneous tissues, with the muscle compartment seldom affected. When intramuscular swelling is demonstrated, the diagnosis of compartment syndrome should be considered.[6] Ultrasound may therefore provide the answer.

There is frequently a degree of cross-over between cytotoxicity and haemotoxicity in cytotoxic envenomations. This means that fasciotomy may result in catastrophic bleeding and should be preceded by the administration of antivenom, especially in patients with a low platelet count or a high INR.[3] Deranged clotting profiles or low platelets will be resistant to correction until antivenom has been given. Our institution follows a protocol of antivenom administration prior to fasciotomy to reduce intraoperative bleeding. Only patients who underwent fasciotomy did not receive antivenom, and these were delayed presentations (>48 hours after envenomation).

Conclusion

The syndromic management of snakebite is effective and safe. There is a high incidence of anaphylactic reactions to antivenom, and its administration must be closely supervised. In our area we overwhelmingly see cytotoxic snakebites with PPS. Surgery is often needed, and we need to refine our algorithms in terms of deciding on surgery.

Acknowledgements. None.

Author contributions. All authors: substantial contributions to the conception and design of the work; acquisition, analysis, and interpretation of data for the work; drafting the work and revising it critically for important intellectual content; final approval of the version to be published; agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Funding. None.

Conflicts of interest. None.

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Accepted 17 July 2017.