Commissioned article: management of exotic snakebites

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Summary

Exotic (foreign or non-native) snakes, including venomous species, are becoming increasingly popular pets in Western countries. Some of them are kept illegally (as defined by the UK Dangerous Wild Animals Act of 1976). There is a large international market for such animals, with contraventions of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). In the UK, several other European countries and the USA the reported numbers of bites by venomous exotic snakes, although small, are increasing but still underestimate the occurrence of these occasionally fatal events because of the victims’ reluctance to seek medical care. Victims are predominantly young men who have been drinking alcohol. Bites may be intentionally provoked. In Europe, the species most often involved are cobras, green mambas, American pit vipers particularly rattlesnakes, African adders, vipers and Asian green pit vipers. To illustrate the special problems involved, case histories are presented of bites by exotic species in the UK and of bites abroad, where patients were repatriated for treatment. In view of the relative rarity and diversity of these cases, expert advice must usually be sought. These requests should include information about the species thought to have been responsible and the history and timing of the evolution of envenoming. Sources of advice and antivenom are discussed together with recommendations for appropriate first aid and emergency treatment while this is being awaited. Respiratory and cardiovascular resuscitation may be required and when systemic or severe local envenoming develops, specific (equine or ovine) antivenom is indicated.

Exotic snakes in captivity: quantity and diversity

Snakes, despite their unpopular public image, are often kept as pets. Famous enthusiasts include the former mayor of London Ken Livingstone, film actor Nicolas Cage and the late notorious Kray twins. Reggie and Ronnie owned pet boa constrictors, named Gerrard and Nipper after the two detectives who successfully booked them for murder. How prevalent is this passion for snakes?

The London Daily Mail of 17 April 1997 carried the striking headline: ‘In a suburban garage, killers by the dozen. RSPCA seizes collection of some of the world’s deadliest snakes’. In May 1996, 58 illegally held venomous snakes had been found in a home in Sutton. The cache included Asian spitting cobras, African saw-scaled vipers, American rattlesnakes and Australian Collett’s snakes. Rare exposés such as this, reveal what has been called the ‘underground zoo’, an unknown number and diversity of exotic (foreign or non-native) venomous snakes, spiders, scorpions, centipedes and other dangerous animals held by amateur enthusiasts, many of them illegally.

On the international black market, the trade in exotic animals is thought to be second only to drugs and weapons. The largest importer of reptiles...
in the world is USA, with a market worth at least US$15 billion annually. About 1.5–2.0 million US households keep one or more pet reptiles, perhaps as many as 7.3 million animals in all. Eleven percent of the imported reptiles are snakes, 9% of which are venomous species. Customs’ seizures of snakes illegally imported into the UK in recent years have included some rare and endangered species such as a pair of burrowing cobras [Naja (Paranaja) multifasciata duttoni], possibly from Cameroon. CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) regulations are regularly contravened.

Bites by exotic snakes in the USA and Europe Union: numbers and severity

Although venomous snakes are rarely if ever aggressive, they will bite if sorely provoked, as shown by the sad case of Boonreung Buachan. In 1998, he won a Guinness World Record title after living with 100 cobras in a glass case in Bangkok for >1 week, but 2 years later, he was killed by one of them (The Independent, London, 23 March 2000).

From 1995 to 2004, the Toxic Exposure Surveillance System database of the American Association of Poison Control Centers recorded envenomings by 77 species of exotic snakes, an average of 39.9 each year with a total of three fatalities. In 2005, there were 98 envenomings, 8 of them life-threatening or debilitating but without any fatalities. Reports from several European countries also suggest that the practice of keeping exotic venomous snakes at home is increasing and with it, the risk of envenoming. In Hungary, 76.3% of all snakebites during the period 1970–2006 were caused by 19 different species of exotic venomous snakes. In Germany, bites by exotic snakes also outnumber those by indigenous Vipera. In the UK, Alistair Reid was consulted for about 32 bite cases by 14 different species (rattlesnakes 10; puff adders 5) in 17 people with no fatalities during the 8 years (1970–77). Two cases were life-threatening and six had developed local necrosis. Since 1986, I have been involved in the successful management of more than 43 cases of exotic snakebite in 36 people in the UK, caused by 26 different species, 3 cases of venom of 3 species entering the eye and 9 cases in people who returned to UK with residual problems after being bitten abroad by 9 different species. Undoubtedly, there were many more cases than this, those managed by other physicians or the ones not seeking hospital treatment. More than 115 venomous species are known to be held legally in this country (E. Blamey and R. Harrison, personal communication, 2009) while a survey in Sweden discovered that 125 species of exotic snakes were being kept. Some of the most popular exotic snakes and frequent causes of envenomings are Egyptian, Indian and Thai monocellate and piebald spitting cobras (genus Naja); green mambas (Dendroaspis angusticeps); Western diamond-back rattlesnakes (Crotalus atrox) (Figure 1); copperhead moccasins and cantils (genus Agkistrodon); bush vipers (genus Atheris); puff adders, Gaboon and rhinoceros-horned vipers (genus Bitis); desert horned-vipers (genus Cerastes); and white-lipped green pit vipers (Cryptelytrops/Trimeresurus albolabris) (Figure 2) often referred to incorrectly as ‘Pope’s pit viper’ which is Popeia/Trimeresurus popeiorum).
Victim profile

Prominent among the owner-victims of exotic snakes are macho, inebriated young men whose hobbyist websites sometimes reveal worrying psychopathology. In eight cases of exotic snakebite treated in Berlin, blood ethanol concentrations on admission ranged 26.1–91.3 mmol/l (120–420 mg/dl). Colleagues in the USA have taught me the characteristics of their typical snakebite patients, encapsulated as the ‘7 T’s’: Tattoos, Testosterone, Tequila, T-shirt, Truck (with gun rack), Teasing the snake and Teeth (missing). Many of these features are shared by European victims of exotic bites.

Circumstances of bites

People are bitten by exotic snakes while handling or feeding them, cleaning out their cages, milking them of their venoms or attempting to steal them. Bites occur most commonly when they are handled carelessly, usually late at night after taking alcohol and other recreational drugs and while in a tired and emotional state (see Case 1 below). However, even sober professionals make mistakes. Two distinguished herpetologists, Karl P. Schmidt and Robert Mertens, died after being bitten by exotic colubrid species, the potency of whose venoms they had underestimated. Serious envenoming has resulted from bites by Colubridae species that were not thought to be venomous, and there is emerging evidence that many members of this family, once considered non-venomous, are capable of causing local envenoming, including species such as North American garter snakes (genus Thamnophis) and hog-nosed snakes (genus Heterodon) (Figure 3), which are popular pets (Figure 4). Some rare venomous species that apparently never bite indigenous people in their native lands have managed to reveal their dangerous potential only by biting snake keepers in the West. Homicides (‘Speckled Band Syndrome’) and suicides (‘Cleopatra Syndrome’) by snakebite or injection of venom have been described.

Illustrative UK case histories

Patients bitten in UK

Case 1

A 34-year-old man kept exotic venomous snakes in his back garden. One night, distressed by marital problems, he provoked a Southern Pacific rattlesnake (Crotalus oreganus/viridis helleri), 124 cm in total length, to bite him on the back of his left wrist. He had been bitten previously by a Russell’s viper (Daboia siamensis), Egyptian cobra (Naja haje) and twice by a western diamondback rattlesnake (C. atrox) (Figure 1), but had sought medical help for only the most recent of these bites, 4 months earlier. He presented to hospital 3 h later at 0200 h when he was fully conscious but confused, violent and vocal after drinking more than a bottle of whisky. He refused to divulge which of his snakes was responsible, but eventually suggested it was a C. Atrox. Three days later he remembered that it was in fact a C. o. helleri. Swelling extended to the left elbow. Widespread coarse muscle tremors affected especially facial and shoulder girdle muscles. Myokymia is now a recognized neurotoxic feature of C. o. helleri envenoming. An appropriate antivenom was requested from the National Poisons Centre in London and delivered by the police. Over the next 12 h, his condition deteriorated. His pulse rate fluctuated between 150 and
antivenom by intravenous infusion, he felt much better, muscle tremors subsided and his pulse rate fell. Six hours after the antivenom, bleeding from venipuncture sites had ceased and thrombocytopenia and coagulopathy were resolving. Three days later, he took his own discharge from hospital and disposed of his entire snake collection. He was in excellent health when seen 1 year later.

**Case 2**

A 46-year-old man was bitten on the left thenar eminence by one of his Western diamond-back rattlesnakes (C. atrox) (Figure 1) in Northern Ireland. He applied a tourniquet above the wrist and presented to hospital where his blood ethanol level was found to be 53.9 mmol/l (248 mg/dl). After the tourniquet was released, swelling spread rapidly to the shoulder and it was decided to fly CroFAb antivenom from Liverpool. He responded well to the treatment. However, in the next 2 years, he was bitten twice more by the same species and required a further costly airlift of antivenom. Soon after this incident, a large consignment of North American copperhead moccasins (Agkistrodon contortrix) arrived in Northern Ireland. A 43-year-old man bought one and was bitten on the left middle finger. He developed painful swelling and redness of the whole arm and left side of his chest, with enlarged axillary nodes. He had a leucocytosis of 15.5 × 10⁹/l, no evidence of coagulopathy but a slightly raised D-dimer. Because of the tense finger and hand swelling, surgeons threatened fasciotomy, which he wisely refused. He was reluctant to stay for any treatment but was finally persuaded to receive 2 ampoules of CroFAb antivenom flown from the National Poisons Information Service Centre in London. His condition improved but he promptly took his own discharge. These cases of snakebite in Ireland remind one of Frederick Forsyth’s prize winning short story ‘There are no snakes in Ireland’ and question the durability of St Patrick’s legendary ban.

**Patients bitten abroad but treated in the UK**

**Case 3**

A 50-year-old male English physician and amateur herpetologist was bitten on his thumb while handling a saw-scaled viper (Echis ocellatus) (Figure 6) 15 cm in total length in a remote area of North Eastern Nigeria. Six years earlier, he had been bitten on the same digit by a Burmese Russell’s viper (Daboia siamensis). There was immediate pain, early bruising, swelling and throbbing headache and he became pale and anxious. Although
treated promptly with Behringwerke North and West Africa polyvalent antivenom, the local symptoms increased in intensity. He developed fever, tachycardia, thirst, polyuria, a local blood-filled blister, pain in the tips of his fingers, enlarged, painful, tender axillary nodes, incoagulable blood, bleeding gums and a massive haematoma at the site of an intramuscular injection of hydrocortisone. He was flown back to UK and 3 days after the bite necrotic tissue débrided from his thumb (Figure 7) contained unneutralized *E. ocellatus* venom. He made a complete recovery following split-skin grafting and has avoided further bites.

**Case 4**

A 37-year-old male, English, wildlife photographer was bitten on the thumb by a common lancehead pit viper (*Bothrops atrox*) by the Coppename River in up-country Suriname. Almost immediately, he collapsed with transient blindness and unconsciousness. Later, he noticed pain in the bitten limb, painfully enlarged epitrochlear and axillary nodes, fever and thirst. He vomited blood and bile and bled from his gums. He had to wait for 2 days by the side of the road until the first lorry passed. He was driven to the main hospital in the capital Paramaribo. On admission, he was pale, jaundiced and dehydrated. He had passed scarcely any urine since being bitten. His haemoglobin was found to be 5.4 g/dl, plasma electrolytes were normal, blood urea was 62 mmol/l and serum creatinine was 1540 μmol/l. He was given a very poor prognosis by local doctors and flown home ‘hiccuping all the way’. On admission to hospital in London (5 days after the bite), he was exhausted, distressed, pale, but haemodynamically stable. There was a necrotic area on his thumb, but no residual swelling and he had retinal haemorrhages. Haemoglobin had fallen to 7 g/dl and platelet count was $20 \times 10^9$/l. There was a mild coagulopathy (prolonged Reptilase time) with raised fibrinogen degradation products. Schistocytes were seen on the blood film, suggesting microangiopathic haemolysis. Plasma electrolytes were normal, urea was 62 mmol/l and creatinine was 1590 μmol/l.

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**Figure 6.** West-African saw-scaled viper (*Echis ocellatus*): commonest cause of serious snakebites in many West African countries and responsible for Case 3.

**Figure 7.** West-African saw-scaled viper (*Echis ocellatus*) bite (Case 3): showing débridement of necrotic tissue from the site of the bite after 3 days.
Haemodialysis was started but thrombocytopenia and coagulopathy persisted for 9 days until he was treated with Wyeth (Crotalidae) polyvalent antivenom. He made a complete recovery.

Clinical management: the need for expert advice

Having to deal with a patient bitten by an exotic snake is a rare experience for any Western clinician, but it may become more frequent. Most will lack the experience and knowledge to manage such an emergency and must seek expert advice as a matter of urgency.

Key information to be provided to the expert consultant

Species of snake responsible

Exotic snakebite victims/owners usually know the identity of the snake responsible but may use misleading snake names. The ‘Western hog-nosed viper’ is strictly a Central American pit viper (*Porthidium ophryomegas*), but this name has been used mistakenly for a North American colubrid, the Western hog-nosed snake (*Heterodon nasicus*) (Figure 3). A ‘South American Parrot snake’ could be a pit viper *B. bilineatus*, but this name is usually applied to the colubrid *Leptopsis ahaetulla*. ‘Mangrove snake’ could mean a South Eastern Asian pit viper (*Cryptelytrops/Trimeresurus purpur eomaculatus*), but usually refers to colubrids, either the South Asian *Boiga dendrophila* or Floridan *Nerodia clarkii compressicauda*.21 Another difficult and increasing problem is created by the hybridization of venomous species in captivity such as, the *Bitis gabonica* x *B. nasicornis* hybrid (known to hobbyists as ‘Gabino’), which has also occurred in the wild.22 It may be possible to call on a local expert (herpetologist) to examine and identify the snake (see below).

History and evolution of envenoming

The following details are necessary:

(i) Time and anatomical site of the bite.
(ii) Signs of local envenoming: pain, swelling (extent and rate of spread), bleeding, lymphangitis, bruising and blistering.
(iii) Painful, tender enlargement of local lymph nodes draining the bitten limb.
(iv) Signs of systemic envenoming: hypotension, ECG abnormalities; spontaneous systemic bleeding (e.g. from gums, nose, intestinal, urinary or genital tracts); ptosis (not just drooping eyelids at rest; failure to elevate upper lids on upward gaze), bulbar/respiratory paralysis; myalgia (rhabdomyolysis); and acute renal failure.
(v) Laboratory tests: full blood count (neutrophil leucocytosis), blood film (microangiopathic haemolysis), platelet count, coagulation screen, D-dimer, plasma electrolytes, creatinine, serum creatine kinase, urine dipstick for blood/haemoglobin/myoglobin and urine microscopy.

Only about 50% of bites by exotic venomous snakes inject sufficient venom to cause clinical envenoming, but signs may not appear for hours. Because of the danger of delayed evolution of severe envenoming, patients presenting with a history of snakebite should be observed in hospital for a minimum of 24 h (see below).

Spitting elapids squirt their venom into the victim’s eyes, causing painful chemical conjunctivitis with the risk of corneal ulceration, anterior uveitis and secondary infection.

How to get expert clinical advice and locate antivenom

Bites by exotic venomous species form a tiny but disproportionately challenging part of poison centres’ work load. In the UK, clinical advice and antivenoms are available via the National Poisons Information Service 0844 892 0111 and at Toxbase http://www.toxbase.org/. The Department of Health aims to cover all venomous species known to be held legally in zoos, institutions and licensed private homes or suspected to be kept illegally. Currently, 18 different snake antivenoms, 1 for fish, 2 for spiders and 3 for scorpions are stocked. Legal keepers, especially zoos, are encouraged to keep an initial dose of antivenom specific for their species, to be brought to the hospital with the patient. Anti-venom is supplied by pharmacies in London and Liverpool. Each pharmacy stocks enough antivenom to treat at least two cases of severe envenoming. These holdings are linked into the European Zoos Network coordinated by the Poison Centre Munich. Its MAVIN web-site http://www.toxinfo.org/antivenoms/synopsis.html lists the locations of stocks of different specific antivenoms.

Sweden has a 24 h private pharmacy supplying 20 different antivenoms for exotic venomous animals (CW Scheele, Stockholm).

In the USA, the regional poison centre (001-800-222-1222) can be contacted. Other sources of information are the Oklahoma City Anti-venin Index (1-405-271-5454), Poisonex central office in Denver, Colorado, (1-800-332-3073), the Association of Zoos and Aquariums and American Association of Poison Control Centers Online Antivenom Index (limited access) http://www.aza.org/ai
and Miami-Dade Fire Rescue Anti-Venin Bank (1-786-336-6600).3, 4

Snake identification
Local zoos can help identify the species of snake.23, 24 A description over the phone or, increasingly, transmission of an electronic image (by e-mail or mobile phone) may allow diagnosis. It may prove possible for a snake expert (herpetologist or zoo reptile keeper) to visit the patient’s home to identify the snake.

Emergency treatment (while awaiting expert advice)

First aid (pre-hospital)
Emergency advice might be sought by phone, immediately after the bite and before the patient has started his/her journey to the hospital. In this situation, provided that the necessary materials and trained personnel are available (for example at a zoo or research institution), pressure-immobilization (PI) is recommended until or unless a bite by a neurotoxic elapid snake (cobra, mamba, krait, coral snake, Australasian venomous snake) can confidently be excluded25, 26. The greater the delay in applying PI, the less likely it is to be effective. In extreme circumstances, PI might delay life-threatening bulbar and respiratory paralysis until the patient can be intubated and ventilated on arrival at hospital. After bites by all other species of snakes, PI is not appropriate. For all snakebite cases, immobilization of the whole patient, particularly the bitten limb and rapid transport to medical care, ideally in the recovery position, is recommended. When venom has been spat into the eyes, immediate irrigation with liberal amounts of water or other bland fluid is the best first aid as with any exposure to irritant chemicals. The use of many once-popular first aid methods for snakebite, including tourniquets, local incisions/excisions, vacuum extractors, instillation of chemicals, cryotherapy, electric shock and other horrors, should be discouraged as these methods have proved ineffective and dangerous.

Resuscitation
Snakebite is a medical emergency. Patients may need immediate resuscitation for cardiovascular or respiratory failure. Venom anaphylaxis is a particular hazard for snake handlers and toxinologists who may have become sensitized to venom through previous bites or aerosolized venom.16 Circulating volume repletion is needed if there is massive extravasation into the bitten limb. Early endotracheal intubation and assisted ventilation may be required if descending paralysis progresses.

Release of a PI bandage or a tourniquet may precipitate catastrophic systemic envenoming and so they should be left in place until staff and equipment are assembled to allow immediate resuscitation if it is required. If an appropriate antivenom is available and there are signs of systemic envenoming when the patient arrives in hospital, this treatment should be started before occlusive bands are released.


Monitoring and observation of snakebitten patients

Published clinical grading systems for scoring the severity of envenoming when the patient is admitted to hospital consist of arbitrary collections of symptoms, signs and laboratory data of unproven prognostic significance. Such ‘poisoning severity scores’ are dangerously misleading by ignoring the contingency of sudden deterioration and rapid progression of local and systemic envenoming. Because of these uncertainties, snakebitten patients must be closely monitored at frequent intervals, preferably in an intensive care unit. New symptoms, extent of local swelling and vital signs must be recorded for at least 24 h after admission to cover the possibility of delayed appearance of envenoming. Depending on the species of snake involved, clinical and laboratory measures of haemostatic disorders, cardiotoxicity, early signs of neurotoxicity (ptosis and descending paralysis of muscles innervated by cranial nerves III, IV, V, VI, VII, X, XI, XII and especially signs of impending bulbar and respiratory paralysis) and rhabdomyolysis and urine output/colour should be recorded.

Persuading the patient to remain long enough to be observed and treated

Victims of exotic snakebites are often reluctant to seek medical attention for fear that their illegal reptiles be confiscated and are keen to leave hospital as soon as possible (see Cases 1 and 2 above). They may be sceptical of medical advice because they know more about snakes and their venoms than the doctors who are treating them. They may refuse antivenom because they have experienced
reactions to treatment of previous bites or fear becoming sensitized.

**Dissuading surgeons from carrying out unsafe and unnecessary fasciotomies**

Local effects of envenoming often result in a painful, tender, immobile, pale, cyanosed, cold, tensely swollen and apparently pulseless limb with poor capillary refill. Surgeons are commonly beguiled by these appearances and may insist on fasciotomy. However, intracompartmental pressures are usually well below the threshold of 30–40 mmHg. Fasciotomy is dangerous before normal haemostasis has been restored with antivenom. Inexperienced surgeons may mistake bruised for necrotic muscle and débride unnecessarily. In any case, myofibrils damaged by some snake-venom phospholipases $A_2$ will regenerate if the muscle is left intact.\textsuperscript{30} Even in those cases of compartmental hypertension that have resulted from envenoming, there is considerable doubt whether fasciotomy affects the prognosis of the intracompartmental muscles. \textsuperscript{31}

**Prevention of bites by exotic snakes**

In the UK, a licence is statutory for those keeping animals defined as dangerous by Department of Environment Food and Rural Affairs (http://www.defra.gov.uk/wildlife-countryside/protection/dwaa/index.htm). Victims of exotic snakebites must be advised to get rid of their venomous animals or to improve safety by discussion with experts at zoos or consulting the literature.\textsuperscript{32–34} Zoos and research institutes must establish clear protocols for dealing with accidents involving venomous snakes.\textsuperscript{35}

**Acknowledgements**

I am most grateful to Dr Mark Papouchado, Dr Oliver Garai, Dr Hugh J.M. Williams, Prof. J. Stewart Cameron, Mr Fazel T. Fatah, Dr David G. Lalloo, the late Dr Bent E. Juel-Jensen and many other clinicians who have involved me in the care of patients bitten by exotic snakes in the UK and to Prof. R. David G. Theakston, Mark O’Shea, Paul Rowley, the Zoological Society of London and Guy’s St Thomas’ Poisons Information Centre for their help.

*Conflict of interest:* None declared.

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