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Red-bellied black snake envenomation in dogs

Red-bellied black snake (*Pseudechis porphyriacus*) envenomation in 17 dogs: clinical signs, coagulation changes, haematological abnormalities, venom antigen levels and outcomes following treatment with a tiger-brown snake antivenom

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Abstract

This report describes 17 cases of red-bellied black snake envenomation (RBBS; *Pseudechis porphyriacus*) in dogs in south-eastern Queensland. Patients were prospectively enrolled for treatment with a new Tiger-Brown Snake Antivenom 8000 units, (TBAV; Padula Serums Pty Ltd, Australia). Clinical diagnosis of RBBS envenomation was made by either snake venom detection kit, snake identification using scale counting or owner observed dog-snake interaction in patients with clinical signs of envenomation. A RBBS venom antigen sandwich ELISA was used to retrospectively quantify venom levels in frozen serum and urine. Mechanical ventilation was required in 11% (2/17) patients, whole blood transfusion in 12% (2/17), tissue swelling at the bite site occurred in 53% (9/17) and facial palsy in 12% (2/17). One dog was euthanised and overall, 94% (16/17) survived to hospital discharge. Clinicopathological changes pre-TBAV included variable haemolysis, increased CK, pigmenturia and mildly prolonged ACT with a median of 134 s (n=13, range 91 – 206 s). Haematological profiles post-envenomation revealed anaemia (6/6) and spherocytosis (5/5) which resolved without the use of corticosteroids. Pre-TBAV, median RBBS venom antigen concentration was 22.6 ng/mL (n = 15, range 2 – 128) in serum and 58 ng/mL (range 1 – 452) in urine; RBBS venom antigen was undetectable in serum post-TBAV in all patients. Some RBBS envenomed dogs required critical care including mechanical ventilation, blood transfusion, additional antivenom and prolonged hospitalisation. TBAV was effective with excellent prognosis despite stated specificity for tiger and brown snake.

Keywords

snake venom; snake antivenom; snakebite; red-bellied black snake; *Pseudechis porphyriacus*;

enzyme immunoassay

1. Introduction

The *Pseudechis* genus (the black snake group) is one of five groups of clinically important venomous elapid land snakes found in Australia. One of the most common and frequently found black snake species in the populated areas of eastern Australia is the red-bellied black snake (RBBS; *Pseudechis porphyriacus*). In a survey of veterinarians from 253 clinics in New South Wales, the RBBS was reported as the most common snakebite recognised in animals, representing 45% of all snakebite patients treated.¹ The clinical RBBS envenomation syndrome in canines is typically manifested as varying degrees of haemolysis, mild anticoagulant coagulopathy, pigmenturia, myopathy and local tissue swelling.²⁻⁴ Similarly, human envenomation is generally mild, with supportive care and antivenom treatment administered only in severe cases.⁵ However, recent veterinary case reports have described severe life-threatening complications from RBBS envenomation including acute neurotoxicity, marked haemolysis and death.^{2, 6-8} There remains a paucity of information on the RBBS envenomation syndrome in dogs, which appears more severe than described in humans. Consequently, more veterinary specific knowledge is required on this snakebite in dogs, the range of clinical signs, and venom effects to better guide veterinarians in administration of appropriate and cost-effective treatment.

The current clinical knowledge regarding RBBS envenomation in dogs is based upon a limited number of published case reports and anecdotal information amongst veterinarians. A potentially fatal acute neurotoxicity requiring mechanical ventilation for 18 h with a successful

outcome was described in a RBBS envenomed dog.⁸ This contrasts to a series of 81 human cases in which acute neurotoxicity was not observed.⁵ A veterinary case report describes a dog that was euthanised with anuric acute kidney injury, marked intravascular haemolytic anaemia and rhabdomyolysis, despite receiving antivenom 15 h after envenomation.⁹ Severe haematological complications following RBBS envenomation were described in a separate case report that required whole blood transfusion due to ongoing severe haemolysis.⁷ The presence of spherocytes in dogs following RBBS envenomation has also been sporadically described in veterinary case reports.^{2, 6, 7}

A combined tiger and brown snake antivenom product is generally administered to RBBS envenomed veterinary cases that are presented to veterinarians for treatment because of its utility. This is based on the knowledge that tiger snake (*Notechis scutatus*) antivenom can effectively neutralise the lethal toxins present in RBBS venom. There is considerable immunological cross reactivity with the neurotoxin and myotoxin called notexin found in tiger snake venom with pseudexin found in RBBS venom.^{10, 11} Whilst cross reactivity has been demonstrated for acute lethal neurotoxins, the ability of tiger snake antivenom to prevent severe haemolysis with RBBS envenomation is unclear. A specific black snake antivenom for human use is made with *P. australis* as the immunising antigen, but it is not typically used for RBBS patients (human or animal) in Australia due to its higher volume and cost; instead it is preferred only for severe *P. australis* envenomations.¹² In recent decades bivalent veterinary antivenom in Australia has been formulated to contain not less than 3000 units of neutralising activity for tiger and 4000 units for brown snake. Recent studies of the milked venom yields of tiger and brown snakes has shown that venom mass is more variable and greater than previously

measured and the authors suggested that higher doses of antivenom may be required than previously considered.¹³ A newly licensed veterinary antivenom has recently become available in Australia containing 4000 neutralising units against tiger snake venom per vial which is more than the other currently available products.¹⁴ The product is a whole equine IgG caprylic acid fractionated bivalent antivenom and has demonstrated efficacy in previously published reports.^{2, 7, 8}

The aim of this study was to describe the range of clinical features associated with RBBS envenomation in dogs in south-eastern Queensland and their response to treatment with a new tiger-brown snake antivenom.

2. Materials and Methods

Study Design

RBBS envenomated dogs received the new tiger-brown antivenom treatment at a veterinary referral hospital (Veterinary Specialist Services, Underwood) and afterhours emergency service (Animal Emergency Services, Underwood) in south-eastern Queensland, Australia, from October 2016 to March 2019.

Diagnosis and Treatment

A standard treatment protocol was implemented for each patient. On presentation, physical examination and triage was performed depending on the animal's condition and clinical status. Veterinarians made the presumptive diagnosis of RBBS envenomation based on at least one of

the following: owner history of observed dog-snake interaction or positive snake identification by scale counting and suggestive clinical signs or a positive urine snake venom detection kit¹⁵ for black snake (SVDK; Seqirus, Parkville, Australia). The SVDK has been found to be highly specific for detecting snake venom in urine.¹⁶

Patients were treated with an experimental antivenom that has since become a licensed veterinary medicine for use in Australia: Tiger-Brown Snake Antivenom 8000 units (TBAV; Padula Serums Pty Ltd, Australia. APVMA Approval No. 83903/109217).¹⁴ An intravenous (IV) catheter was placed in the cephalic vein and TBAV administered either manually via slow push or using a constant rate infusion (CRI) syringe pump diluted with saline. A range of infusion rates were used decided by the clinician at the time based on patient severity. During TBAV administration the patient's vital signs were closely monitored for adverse reactions including mucous membrane colour, heart rate, respiratory rate and effort, temperature, blood pressure, and blood oxygen saturation. Additional vials of TBAV were administered throughout hospitalisation at the discretion of the attending veterinarian.

Venous blood samples were collected pre- and 2 to 4 h post-TBAV. Packed cell volume (PCV) was measured using micro-haematocrit tubes spun in a centrifuge, total plasma protein (TP) estimated with a handheld refractometer and serum was assessed for presence of visible gross haemolysis. Coagulation times were assessed using active clotting time (ACT) test by collecting 0.5 mL or 2 mL of whole blood in a grey or black tube respectively (Actalyke, Helena Laboratories, Mt Waverly, Australia) and immediately placed into a single well whole blood coagulation time monitoring instrument (Hemochron 401, Edison, New Jersey). Normal ACT reference ranges were 90 – 120 s for black top tubes and 60 – 90 s for grey top tubes. In

patients presenting with respiratory compromise, measurement of venous blood gas was performed to assess the partial pressure of carbon dioxide (pCO₂). Samples for subsequent RBBS venom antigen analysis were collected using 1 mL of whole blood that was placed in a plain tube at room temperature for approximately 1 h, centrifuged, the supernatant collected and frozen within 4 h of collection. These steps were repeated between 2 to 6 h post-TBAV and throughout hospitalisation at the discretion of the veterinarian. Haematology and biochemistry tests were performed in-house using an automated analyser (VetScan; REM Systems, Australia) or with an external veterinary diagnostic laboratory (QML, Brisbane, Australia).

All patients received continuous veterinary nursing care during hospitalisation. This involved monitoring of all vital signs, recumbency changes, passive range of motion physiotherapy, eye and bladder care, IV catheter checks, active warming and monitoring bladder size. Each patient received IV fluids consisting of Hartmann's or Plasma-Lyte 148 (Baxter, Australia). Pain relief was administered a full μ agonist such as methadone (Methadone Injection, Jurox, Australia; 0.3 mg/kg SQ or 0.1 mg/kg IV) and some patients were transitioned to a transdermal fentanyl patch (Durogesic®, Janssen, Australia; 2 - 4 μ g/kg). In patients requiring sedation, butorphanol (Butorgesic Injection, Ilium, Australia; 0.2 mg/kg, SQ) or acepromazine (ACP 2, Ceva, Australia; 0.02 mg/kg, SQ) was administered. In patients that required mechanical ventilation (MV), total intravenous anaesthesia (TIVA) with CRI of midazolam (Midazolam, Sandoz, Australia; 0.1 – 0.5 mg/kg/hr), butorphanol (Butorgesic Injection, Ilium, Australia; 0.1 – 0.3 mg/kg/hr) and propofol (Propofol-Lipuro 1%, Braun, Australia; 5 – 15 mg/kg/hr) was utilised. If indicated, anti-emetics were administered including

maropitant (Cerenia Injection, Zoetis, Australia; 1 mg/kg, IV) and/or gastroprotection including esomeprazole (Nexium IV Powder for Injection, AstraZeneca, Australia; 1 mg/kg, IV BID) or omeprazole (Losec Tablets, AstraZeneca, Australia; 1 mg/kg, PO BID). In patients with significant haematuria, an indwelling urinary catheter was placed to monitor urine output and ensure patient comfort, with urine output measured every four hours.

When indicated, MV and blood transfusion were performed using a previously described protocol.^{7, 14} Packed red blood cells (pRBC) were administered for acute anaemia with PCV < 20% and presence of any transfusion triggers including tachycardia, tachypnoea, hypotension and dull mentation. Plasma transfusion was indicated if a dog had prolonged clotting times and was considered at high risk of bleeding. Whole blood was indicated if both red blood cells (RBC) and clotting components were required.

Serum and Urine RBBS Venom Antigen Concentration

The concentration of RBBS venom antigen in frozen-thawed serum and urine samples was retrospectively determined using a specific sandwich ELISA as described previously.²

Data Extraction

Patient data was collated retrospectively, and parameters of interest were extracted including pre- and post-TBAV clinical pathology, hospital stay length, number of TBAV vials and mortality status amongst others (Table 1). Gait and respiratory scores were given to reflect the severity of clinical signs at initial presentation using a modified tick scoring system as previously described¹⁴ (Table 2).

3. Results

Clinical Findings and Outcomes

A total of 17 patients with RBBS envenomation presented during the study period (Table 1). Two of these patients have been previously published as comprehensive case reports.^{7,8} On initial presentation clinicians made a specific diagnosis in 41% (7/17) of patients based on a positive urine SVDK result for black snake venom. Of the patients in which the SVDK was used 100% (7/7) of were diagnostic for black snake. The remaining patients were presumptively diagnosed based on owner observed dog-snake interaction in 29% (5/17) or positive identification of the dead snake in 47% (8/17) with consistent clinical signs of envenomation (collapse episode, hypersalivation, vomiting, haemolysis, spherocytosis, pigmenturia, increased CK, local bite site swelling and/or coagulopathy).

All dogs were treated with IV TBAV. One vial of TBAV was administered to 52% (9/17), two vials to 41% (7/17) and three vials to 5% (1/17) of dogs. In patients where multiple vials of TBAV were administered this was generally done serially on arrival or shortly after obtaining a positive SVDK result. However, in 11% of patients (2/17) a second or third vial of TBAV was administered due to severe haemolysis on day three and four of hospitalisation. Blood transfusion was required in 11% (2/17) of patients, mechanical ventilation in 11% (2/17) and pigmenturia developed in 47% (8/17) patients with a urinary catheter placed in 88% (7/8) of these. Other noteworthy clinical signs included tissue swelling at the bite site in 53% (9/17) (Figure 1) and facial palsy in 12% (2/17) (Figure 2). Only 6% of patients (1/17) developed clinical bleeding abnormalities which manifested as acute onset hematemesis. Pain relief was

administered in 94% (16/17). The median duration of hospital stay was 1 d (range 1 – 6). Overall, 94% (16/17) patients survived to hospital discharge and only one dog was euthanized due to significant clinical deterioration.

The majority of dogs in this series initially presented with mild clinical signs, respiratory scores ranging from A to B and gait scores from 0 to 1; however, severe respiratory distress and generalised weakness was seen in one patient, whilst another developed respiratory distress during hospitalisation. Patient No. 5 (Table 1) presented with excessive salivation with neck ventroflexion. Due to multiple regurgitations, hypoxaemia despite oxygen supplementation and poor respiratory excursions, the patient was rapidly intubated and placed on MV for 18 h⁶. Patient No. 8 presented lethargic but ambulating normally, hypersalivating, prior vomiting and marked pigmenturia. One vial of TBAV was administered on presentation. Approximately 8 h post-TBAV administration bilateral hyphaemia had developed, the PCV had dropped to 19% due to severe haemolysis and 1 unit of pRBC (10 mL/kg) was administered. Samples for complete blood count and biochemistry were sent to an external laboratory (QML) and revealed severe haemolysis, mild anisochromasia and spherocytes. Creatinine had increased by > 150% over 15 h from presentation 56 $\mu\text{mol/L}$ (44 – 159 $\mu\text{mol/L}$) in house, to 140 $\mu\text{mol/L}$ (40-140 $\mu\text{mol/L}$) at the external laboratory. Over the next 15 h the patient continued to deteriorate, and the dog developed acute onset haemoptysis with a prolonged ACT (184 s black top). Oxygen supplementation commenced and 2 units (20 mL/kg) of fresh frozen plasma (FFP) was administered over 4 h, MV was implemented due to severe respiratory effort and hypoxaemia (SpO_2 78%). Thoracic radiographs demonstrating a mild-to-moderate alveolar lung pattern involving the left and right caudal lung lobe (Figure 3) and

thoracic ultrasound showed moderate B lines. Over the next 9 h the PCV continued to drop to 14% and the decision made to administer whole blood to provide both pRBC and plasma components. The PCV increased to 24% and ACT had decreased to 153 s (90-120 s) after a further 8 h. After 48 h from presentation the dog became oliguric with a urinary output of 0.48 mL/kg/hr, which didn't improve with two crystalloid boluses of 20 mL/kg and 1 mg/kg frusemide. The dog became anuric and hypotensive by 48 h a dopamine CRI at 10 µg/kg/hr improved the blood pressure. The owners elected to euthanize the dog at 55 h due to its significant deterioration.

Patient No. 11 was administered a second vial of TBAV and pRBC at 84 h post TBAV when the PCV fell to 15%. The PCV improved to 22% following blood transfusion. This patient developed large soft subcutaneous swelling at the left commissure of the lip with marked facial palsy and reduced blink requiring eye care for one month following envenomation. This is a noteworthy clinical sign that developed in 12% (2/17) of patients (Figure 2).

Patient No. 16 was also administered a second vial of TBAV due to ongoing haemolysis. On initial presentation the PCV was measured at 41%. However, throughout day two of hospitalisation its PCV showed a gradual decline to 24% at which point a second vial of TBAV was administered approximately 33 h later. On day three and four of hospitalisation the PCV remained at 25%.

Clinicopathological Parameters

CBC was performed in 35% (6/17) patients post-envenomation (range 6 – 32 h) and of the patients that had a pathologist review the blood film, varying degrees of spherocytosis were noted in 100% (5/5) patients. On initial presentation, the majority of patients presented with a PCV within normal reference range of $49\% \pm 10$. Serial PCV monitoring was performed in 70% patients (12/17), with PCV dropping between 35-55% in 41% (5/12), between 30-20% in 33% (4/12) and $< 20\%$ in 25% (3/12).

Patient No. 11 had repeated blood smears performed until spherocyte resolution with highest number counts at 5 d post envenomation and gradually declined to undetectable after 62 d.⁷ This patient received a single dose of dexamethasone (0.5 mg/kg SQ) at the time of blood transfusion due to continued haemolysis. No other patients received corticosteroids.

Serum biochemistry data was available in six patients immediately post-envenomation and revealed moderate to severely increased CK values with the highest levels measured at 2 – 3 d post-TBAV, persisting up to 9 d post-TBAV administration. Total bilirubin was increased in 33% patients (2/6) and liver enzymes (ALT, ALP) in 83% of patients (5/6).

Serum and Urine RBBS Venom Antigen Concentrations

The median RBBS venom antigen concentration pre-TBAV in serum was 22.6 ng/mL ($n = 15$, range 2 - 128) and in urine was 58 ng/mL ($n = 12$, range 0.9 – 452). Venom was undetectable in serum post-TBAV in all patients at each time point when samples were collected.

Coagulation Parameters

Prior to administration of TBAV, blood coagulation was assessed by measuring ACT which was found to be mildly prolonged in 86% of patients with a median of 134 seconds (n=13, range 91 - 206).

4. Discussion

This case series demonstrates the potential for RBBS envenomed dogs to occasionally develop severe haemolysis necessitating blood transfusion,^{7,2} infrequently require mechanical ventilation⁸, develop local tissue damage² and need prolonged hospitalisation. Although many of the RBBS envenomed dogs presented with a clinically mild to moderate envenomation there was potential for a fatal outcome. This contrasts markedly to human literature in which no fatalities from RBBS envenomation are reported in the modern era and antivenom is only considered necessary in occasional severe patients due to its high frequency of acute hypersensitivity effects.⁵ Despite the RBBS being a common snake envenomation of dogs in regions of Australia where it occurs relatively little has been published on the syndrome.

This case series demonstrates the potential for development of ongoing, life-threatening haemolytic anaemia and its complications following RBBS envenomation in dogs. This case series shows that in some dogs there is development of an acute anaemia within 24 - 48 h despite antivenom administration, occasionally necessitating blood transfusion. This is consistent with previous reports^{7,2} and demonstrates that a subgroup of patients continues to haemolyse. This suggests that TBAV may be less efficient in neutralising the unique haemolysins in black snakes or that the haemolytic pathology is rapid and largely irreversible. In a brief

retrospective clinical report of RBBS envenomation in dogs in NSW, 10% of patients were administered a blood transfusion.¹⁷ The authors consider that antivenom is indicated in all cases of canine RBBS envenomation and multiple vials of antivenom should be considered in patients presenting with marked haemolysis. Furthermore, it highlights the importance of patient monitoring with serial PCV during hospitalisation and close monitoring for transfusion triggers.

Spherocytes were readily detected on microscopic blood smear examination in RBBS envenomed dogs within hours of envenomation. The presence of spherocytes may be a rapid, simple, cost effective in-house diagnostic test that could be performed to assist in the diagnosis of RBBS envenomation. A previous study presumed spherocyte formation associated with snake envenomation to be the result of a secondary immune-mediated haemolytic anaemia (IMHA).¹⁸ The current case series suggests this is unlikely because haemolysis and spherocytosis without red cell agglutination occurred within hours of exposure to RBBS venom. Such rapid appearance of morphological abnormalities of RBC shape would suggest that this is a direct action of the venom. RBBS venom is known to cause RBC membrane changes resulting in spherocytosis when evaluated *in vitro*¹⁸ with the action of phospholipase enzymes within RBBS venom previously described.¹⁰ In the present case series, all dogs except for patient No. 11 who received a once off dose, recovered without the use of immunosuppressive medications providing further support that spherocytes in RBBS envenomation are unlikely to be the result of targeting by the immune system. The authors postulate that spherocytes are self-limiting and corticosteroids are not required.

This case series also highlights the significant and persistent myotoxicity observed in RBBS envenomed dogs as previously reported.^{5,9,17} The clinical relevance of this myotoxicity is often considered of lesser importance by veterinarians in establishing a diagnosis of RBBS envenomation but may contribute an important role in prolonged hospitalisation and recovery with values persisting up to 9 d post-antivenom administration. The authors recommend the administration of pain relief to all envenomed animals and consider it a necessary part of treatment. This is based upon human RBBS reports in which myalgia associated with myopathy (detectable as elevated serum CK) may be significant.⁵ Additionally, it highlights the importance of concurrently monitoring renal values with the potential consequence of acute kidney injury (AKI) subsequent to myoglobinuria and/or intravascular haemolysis. This was a concern for patient No. 8 which presented non-azotaemic with increasing creatinine values over 15 h, IRIS grade 1 AKI.¹⁹ The dog went on to become anuric by 48 h hospitalisation and was subsequently euthanised. A recent case report also describes the development of anuric acute kidney injury 24 h after presentation due to severe myohaemoglobinuric pigmenturia despite receiving tiger-brown antivenom 15 h after envenomation.⁹

The majority of canine patients in this series developed a mild coagulopathy which has been previously described in human^{5, 20} and dogs.^{2, 6} Recent *in vitro* studies have demonstrated the *Pseudechis spp.* is unique in having anticoagulant activity at lower venom concentrations and procoagulant activity at higher venom concentrations above 100 ng/mL.²⁰ This likely explains the absence of venom induced consumptive coagulopathy because typical venom levels in humans are lower than this with median concentrations of RBBS envenomation reported at 19 ng/mL.⁵ While the coagulopathic effects of RBBS envenomation did not appear

to be clinically significant in the current study, patient No. 8 experienced acute onset haemoptysis. The RBBS venom antigen concentration pre-antivenom in this case was low at 2.2 ng/mL in serum and 43 ng/mL in urine, however it was suspected to be a delayed presentation and likely had a much higher initial serum venom concentration. It is likely such clinical bleeding abnormalities occurred from the anticoagulant activity, although is considered a rare clinical finding. An alternative explanation which cannot be ruled out is development of disseminated intravascular coagulopathy.

A unique clinical feature noted was the development of facial palsy in two patients which has not been reported in current scientific literature to our knowledge. This case series also demonstrates the powerful local effect of the RBBS venom which persisted for weeks, the importance of diligent nursing care and ongoing owner home care.

The TBAV was effective for treatment of RBBS envenomation, despite the stated specificity for tiger and brown snake. RBBS venom was not detected in serum at any time post-administration. For many decades, tiger snake antivenom has been the recommended treatment of choice for RBBS envenomation due to its cross-reactivity, lower volume and cost than monovalent black snake antivenom.²⁰ Monovalent antivenom made specifically against black snake venom antigens (eg *P. australis*) may be more effective in neutralising the unique haemolysins found in *Pseudechis* sp. venom, but this remains to be demonstrated in a clinical setting. The TBAV proved highly effective in terms of clinical outcomes and bound all free circulating venom in serum.

The current case series further substantiates that urine is a more reliable matrix for venom detection in the clinical setting compared to serum. In most patients the measured venom concentration in urine was notably higher than the sensitivity of the SVDK of approximately 10 ng/mL.¹⁵ Veterinary practitioners should preferably use urine because the RBBS venom antigen concentrations are likely to be higher than in serum.

It is important to acknowledge limitations of the current study. The reality of working in a clinical setting meant authors were not able to perform intensive serial monitoring and follow up to all patients involved. It is recommended that future research describes a complete data set on all patients and increase the sample size. In addition, further research is required to examine the pathophysiology of spherocyte formation with RBBS envenomated dogs.

In conclusion, this case series highlights the potential severity of RBBS envenomation and clinical effectiveness of a new TBAV product. Veterinary practitioners should be aware and proactively detect and manage canine RBBS case complications including persistent ongoing haemolytic anaemia, neurotoxicity and respiratory failure, facial palsy and bite site tissue damage. The presence of spherocytes may be an additional diagnostic utility and resolves without immunosuppression.

5. Acknowledgements

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6. Conflicts of Interest

The Tiger-Brown Snake Antivenom 8000 units used in this study was produced by Dr Andrew Padula of Padula Serums Pty Ltd, Australia.

Table 1. Clinical case summary data for RBBS canine patients in this series.

Patient No.	Weight (kg)	Breed	Pre-AV RBBS antigen concentration (ng/mL)		Initial Urine SVDK	Initial Diagnosis of RBBS	Haemolysis at presentation	MV (h)	Hospital stay (d)	Blood Product Therapy	Initial ACT (s) Result	Bite to AV (h)	Initial Gait Score	Initial Resp Score	No. Vials of AV	Outcome
			Serum	Urine												
1	9.5	Jack Russell terrier	15	255	Black	Dead snake and SVDK	N	ND	3	ND	133 (grey)	1	0	B	2	Lived
2	45	Mastiff X	5.1	64	ND	Dead snake	Y	ND	3	ND	153 (black)	Unsure	0	A	3	Lived
3	34	German short-haired pointer	ND	ND	ND	Dead snake	N	ND	1	ND	93 (black)	Unsure	0	A	1	Lived
4	28	Boxer X	2.0	52	ND	Dead snake	N	ND	1	ND	108 (grey)	Unsure	0	A	1	Lived
5	20	Staffordshire bull terrier	15	452	Black	Dead snake and SVDK	Y	18	6	ND	151 (grey)	4	3	D	2	Lived
6	24.5	American Staffordshire bull terrier	128	ND	Black	Dead snake, SVDK and interaction	Y	ND	1	ND	97 (black)	2	0	A	1	Lived
7	29	American Staffordshire bull terrier	47	ND	ND	Snake interaction	Y	ND	2	ND	176 (black)	Unsure	0	B	1	Lived
8	21	Kelpie X	2.2	43	Black	SVDK	Y	36	3	1 pRBC, 2 FFP, 1 whole blood	141 (grey)	Unsure	0	A	1	Euthanised
9	29	Bull arab	ND	ND	ND	Snake interaction,	Y	ND	1	ND	ND	Unsure	1	A	1	Lived

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haemolysis and bite site swelling																
10	11.3	King Charles Cavalier Spaniel	24	ND	ND	Dead snake	Y	ND	1	ND	100 (grey)	2	0	A	1	Lived
11	10.4	Cavoodle	24	106	ND	Dead snake	Y	ND	1	1/2 pRBC	200 (black)	2	0	A	2	Lived
12	27.2	Australian bulldog	7.1	350	Black	SVDK	N	ND	1	ND	135 (grey)	Unsure	0	A	1	Lived
13	43	Bull arab X	204	ND	Black	SVDK	Y	ND	1	ND	120 (grey)	8.5	0	C	2	Lived
14	54.4	Bull mastiff X	13	580	ND	Snake interaction	N	ND	1	ND	163 (black)	5	0	A	1	Lived
15	22.6	Kelpie X	1.4	36	Black	SVDK	Y	ND	5	ND	ND	24	1	B	2	Lived
16	21.4	Bull terrier X	0.9	29	ND	Dead snake	Y	ND	3	ND	91 (grey)	Unsure	0	B	2	Lived
17	27	American Staffordshire terrier	21	ND	ND	Dead snake & interaction	Y	ND	2	ND	206 (black)	1	0	A	2	Lived

ND=not done. MV=mechanical ventilation. AV=antivenom. FFP=fresh frozen plasma (1 unit ~ 220mL), pRBC = (unit ~300mL)

Table 2. Snake bite severity scoring system

Clinical Sign	Score	Description
Gait	0	no clinical signs
	1	mild paresis, able to ambulate
	2	able to stand/sit unaided but can't walk
	3	unable to stand but can maintain sternal recumbency
	4	unable to maintain sternal recumbency
Respiratory	A	no compromise
	B	mild increase in effort and/or respiratory rate
	C	moderate, respiratory rate < 16 or > 40, minimal excursions, abdominal component
	D	dyspnoea, cyanosis, unsustainable respiratory pattern, respiratory arrest, imminent death

Figure 1. Swelling around the foreleg RBBS bite site (arrow) visible in case No. 17.

Figure 2. Development of facial palsy on right side associated with RBBS bite site in patient No. 5

Figure 3. Left lateral thoracic radiograph of patient No. 8 taken at 19.5 h post-antivenom administration demonstrating a moderate to marked interstitial alveolar pattern. There is no evidence of pleural effusion.

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Title:

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