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Review

"Dry bite" in venomous snakes: A review

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ABSTRACT

It is quite interesting that when a venomous snake bites a person and the victim does not suffer from any signs or symptoms of envenomation. A good percentage of venomous snake bites in humans do occur without venom injection. This phenomenon is termed as "Dry" bite in clinical medicine. Though this was not very uncommon in toxicological practice but, our awareness of this problem has increased. In this article an effort has been made to provide an insight into the incidence, pathophysiology and pathomechanics of this unique medical enigma.

Contents

1. Introduction

Venomous snake bite is considered as a serious and life-threatening medical problem seen not only in the tropics but also in the rest of the world as well. More than 5 million people are bitten by venomous snakes in a year and nearly 100,000 of them succumb to it (Adukauskienė et al., 2011; Warrell, 2010). Similarly, a national mortality survey done in India has shown an estimated 46,000 people dying of snake bite in 2005 (Mohapatra et al., 2011).

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Venomous snake bite could result in varying degree of toxicity, from mild local symptoms to features of serious systemic toxicity like severe coagulopathy, neuroparalysis, multi organ failure, shock and finally death. But, when the poisonous snake bites and the victims have no local or systemic or laboratory features of envenomation, it is termed a "Dry Bite". This accounts for a sizable proportion of venomous snake bites all over the world (Tibballs, 1992; Silveira and Nishioka Sde, 1995; Mead and Jelinek, 1996; Warrell, 2010; Russell et al., 1997; Johnson, 1991). The incidence of "dry bites" has often been reported in any given study on venomous snake bites, but just as a statistical figure without much emphasis on its implications. Dry bite is not unique to any one species of venomous snake and is seen in all the types venomous snake bites but, with varying frequencies. In this article an attempt has been made to highlight the incidence of "dry bite" by the venomous snakes and to list out the reasons and the causes for this surprise and lucky escape for the victims of venomous snake bite. It should be the duty of every clinician to suspect dry bite whenever the local and systemic signs of snake envenomation are not evident with clear cut evidence of snake bite either with the presence of fang marks or the snake being brought to the hospital either alive or dead.

1.1. Inclusion of 'dry bite' in the grading of clinical features of snake bite envenomation

Bites by venomous snakes without envenomation [dry bite] were not recognized until recent years. Clinicians all over the world used to be very sceptical about the very idea of a venomous snake bite whenever there was absence of features of envenomation. The tendency of clinicians was used to be, to brush aside such snake bites as non-venomous ones or the theory that the venom gland was empty used to be a popular explanation (Russell et al., 1997). But, now it is no longer a miracle but a well-accepted clinical entity. Dry bite has been included as an important clinical manifestation in the grading of envenomation by poisonous snakes (Adukauskienė et al., 2011). Depending on the severity of envenoming, which is obviously differ depending on the species of snakes, the cases can be classified as given in Table 1.

1.2. Historical perspectives and the epidemiology of "dry bite"

Many biologists, herpetologists and snake handlers did observe this phenomenon for centuries but they knew very little about the reasons behind it and they did nothing to document it (Russell, 1980). It was Sir Joseph Fayrer, who probably published the first case report where the an account of accidental insertion of one of the fangs of a pet rattle snake while feeding the mouse. Though he did not use the word "dry bite", he did discuss the reasons for not showing the signs of envenomation in a venomous snake bite (Fayrer, 1892). One could find similar instances of venomous snakes wounding humans without envenoming in his "Thanatopidia" a legendary book on snakes in India (Fayrer, 1872). Later on H.M. Parrish et al. (1966); F.E. Russell (1980) discussed in detail about the concept of venomous snake bite without any envenomation. Way back in 1968, H.A. Reid (1968) observed that "more than one-half of the victims of venomous snake bite will have minimal or no poisoning". Later on, several other studies showed that, around 20–60% of the venomous snake bites could fall into the category of 'dry-bite' (Russell, 1980).

Over here in Table 2, few important studies have been discussed, with special emphasis on the venomous snake bites without features of envenomation. However, as we see here, the incidence of "dry-bites" varies with species of venomous snakes and from place to place and also to some extent clinician's criteria and judgement to differentiate between very mild oedema and no local signs.

Kitchens and Van Mierop (1987), Barry S. Gold et al. (2002) in their study have left some cautions that some of the patients who have activation of the sympathetic system due to extreme fear could mimic systemic manifestation of the venom. Extreme panic, fear could result in nausea, vomiting, diarrhoea, syncope, tachycardia, cold and clammy skin akin to snake envenomation. Hifumi et al. (2015) attributed the high incidence of dry bite in their study on the pit vipers, known in Japan as "*habu*" (*Protobothrops flavoviridis*) as compared to the other snakes to their unique fangs. In the W.H.O. guidelines on the management of snake bites, Professor *David Warrell*, has made special mention on the incidence of dry bites in various snakes (Warrell, 2010). It is very fascinating to know that 80% of bites by the sea snakes, one of the deadliest venomous snakes show either mild or no envenomation (Reid, 1975). Highest rate of dry bite is thought to be 70–80%, from *brown snake bites(Pseudonaja* sp.*)* in Australia (White, 2010).

1.3. Etiopathogenesis and pathomechanics of 'dry bite'

It is not possible to pin point the exact reasons for the occurrence of this phenomenon known as 'dry bite'. However, there are many possible explanations for the absence of envenomation in the victim. The incidence of 'dry bite' varies among the species of venomous snakes, and the circumstances under which they bite. The amount of venom injected differs when the snake strikes a prey or it bites in defence as always been seen in human victims where the amount of venom injected would be quite small (Reid, 1968). It also depends on the structure of the fangs, namely the length and location in the mouth, the location of opening in the fangs to deliver the venom, hollow structure like the hypodermic needle or the presence groove in the fangs.

1.4. Possible reasons for the total absence of venom inoculation or injection of very minute quantity of venom which is insufficient to produce clinical or laboratory features of toxicity (de Rezende et al., 1998; Silveira and Nishioka Sde, 1995; Warrell, 2004)

- Natural or acquired immunity of the victim against the snake poison
- Absence of venom in the glands at the time of strike
- Diseased venom glands
- Fangs (venom duct) of the snakes getting obstructed due to calcifications impairing the smooth and swift delivery of the venom while striking. This phenomenon could be a real problem in aged or old snakes (de Rezende et al., 1998).
- Mechanical failure resulting in inefficient lunge of the fangs to deliver the venom from the venom sack to the bite site.

Table 1
Clinical grading of envenomation by the venomous snakes.

Grade	Severity of envenomation	Clinical features
1	No envenomation [Dry Bite]	No local or systemic features
2	Mild envenomation	Local oedema &pain
3	Moderate envenomation	Severe local pain, oedema spreading out of Bite zone with systemic features
4	Severe envenomation	Neuro toxicity, shock, severe coagulopathy, AKI, rhabdomyolysis, massive oedema and any other serious systemic manifestations

Table 2
Summary of the major publications on snake bites showing the frequency of "Dry bite".

Study reference	Incidence (%)	Country of study	Important snakes involved in the study
Silveira and Nishioka Sde, 1995	30–42	Brazil	*Lance headed pit viper and rattle snakes.*
Silveira and Nishioka Sde, 1992	19.23	Brazil	Several types
de Rezende et al., 1998	12	Brazil	South American rattlesnake (*Crotalus durissus SP*)
Kitchens and Van Mierop, 1987	25	Florida, USA	Eastern coral snake (*Micrurus fulvius fulvius*)
Gold et al., 2002	25	Baltimore, USA	Pit Viper
Hifumi et al., 2015	20	Japan	"*Habu*" (*Protobothrops flavoviridis*)
Kularatne et al., 2011	8	Sri Lanka	*Saw scaled viper* (*Echis carinatus*)
Spano et al., 2013	10.9	Central California,USA	Rattle snakes
Warrell, 2010	50	Global	Malayan pit vipers and Russell's vipers
	30	Global	Cobras
	5–10	Global	Saw-scaled vipers
Sanford, 1988	20–30	BRAZIL	Several types
Krupp and Chatton, 1977	50	United States	Several types
Reid, 1975	80	North-west Malaya	Sea Snakes
White, 2010	70–80	Australia	*Brown snake (Pseudonaja* sp.*)*

- Swift movement of the victim could result in an ineffective bite due to imperfect penetration of the fangs (Laurence, 1982)
- Possibility of, the snake to misjudge the distance resulting in a partial penetration of the fangs and losing the venom before the penetration of the fangs (Laurence, 1982)

However, Tun-Pe et al. (1991), refute the popular belief that snakes could deplete their venom stock/store and the subsequent victims could have dry bite. They felt that snakes could never become less poisonous or empty the venom sack in spite of striking several times or even after eating a prey. If a venomous snake bites, and the human victim shows no features of envenomation, it is simply because; it did not deliver enough venom while biting and not that its venom sack was empty (Russell et al., 1997).

1.5. Snake species and the morphology of the fangs

The incidence of "dry bite" varies among species of snakes. There are few species of snakes seen Japan and other Asian countries, which have high incidence of 'dry bite'. *Habu* (*Protobothrops Flavoviridis*), *Yamakagashi (Rhabdophis tigrinus*) are at the top of this list.

Habu (*Protobothrops flavoviridis*), a common venomous snake which has high incidence of "dry bite". This higher incidence of dry bite as compared to the other snakes could be attributed to their unique fangs. The fangs in these dangerous snakes are tubular and about 1.5–2 cm in length and the pore for the release of the venom is placed not at the tip of the fangs but little prior [0.1 cm] as seen in typical *viperids*. *Yamakagashi* (*Rhabdophis tigrinus*) is another, equally venomous snake seen in the same region. This snake has fangs placed little back in the mouth. Though these snakes are large, have short 2 mm long fangs, which are not really tubular and the venom from the gland gets released at the base of the fang. As there is no groove for the venom to flow during the bite, dry bite becomes inevitable, giving false notion that the snake could be a non-venomous one (Hifumi et al., 2015; Morokuma et al., 2011). Some time, the quantity of venom injected could be too small to produce any clinical features of envenomation. There could be mechanical in-efficiency while biting, as only one fang gets penetrated or superficial penetration of the fangs etc. In addition, there could be several other factors like the ability of the snakes to control the venom discharge, to deliver a variable amount of venom injected as per the circumstances related the bite, like striking with fear, while predating on the prey, physical irritation or pain on being stamped by the victim or when it gets threatened, biting in self-defence etc. And again, the venom delivery also depends upon the variable size and species of the snakes (Warrell, 2010). The length of time for which the snake holds on, while biting also could be a deciding factor for the successful envenomation (Russell et al., 1997).

1.6. Venom metering

The delivery of venom by the striking snake is completely voluntary; all the venomous snakes have the ability to bite without injecting the venom through their fangs. Hence, the snakes could vary the amount of venom injected while striking a prey which is to be eaten or when it bites in defence or when irritated. This behaviour is termed as venom metering. The 'dry bite' in the venomous snakes could be attributed to this (Young et al., 2002) On the contrary, some species of rattle snakes said to be increase the quantity of venom on striking in defense than the predatory strikes (Young and Zahn, 2001).

1.7. "Dry bite" by the venomous snakes in relation to lunar cycle

There has been a popular belief that at certain days of the lunar cycle, the snakes tend to contain more poison, any bite at these days results in severe envenomation and during the other days, lesser severity of the envenomation including the 'dry bite'. But, Anil K. Batra et al. in their observational study while analysing the relationship of fatal snake bites on the full moon days and other days categorically found no truth in this belief (Batra and Keoliya).

1.8. Faulty delivery of the venom

For the successful venom delivery, as the snake bites, it is imperative that, while the fangs penetrate the tissue of the victim, the venom flow should coincide. But, it has been found that in certain species of rattle snakes, like Crotalus atrox, the venom flow and fang penetration does not coincide during all the strikes. There used to be occurrence of retrograde flow of the venom much earlier to the withdrawal of the fangs (Young and Zahn, 2001). Some of the "dry bites" could be due to improper timing of the snakes to release the venom prematurely, before the penetration of the fangs (Young et al., 2002).

1.9. Victim's dress material

Sometimes, the victim's clothing could make all the difference. Herbert and Hayes (2009) found that the denim clothing could reduce the venom injection by interfering with the kinetics of venom delivery, in rattle snake bites. This could be a possible explanation for "dry bite" in those who are wearing it.

The final conclusion on the aetiology of "dry bite" would be that the snakes do not get depleted of venom stock but somehow do not deliver the venom while biting (Russell et al., 1997). Due to various reasons venom is either not injected into the body of the victim or, even if it does, there is no envenomation (Adukauskienė et al., 2011).

2. Diagnosis of "dry bite"

The final diagnosis of a 'dry bite' is always a retrospective one. The following considerations should be kept in mind while diagnosing a venomous snake bite as 'dry bite' as a bite by a venomous snake bite does not necessarily mean that there will be envenomation (Cook, 1992; Mead and Jelinek, 1996; White, 1998; de Rezende et al., 1998; Russell et al., 1997; Reid, 1968).

- Offending snake to be identified as a venomous one by the trained clinician/herpetologist if brought alive or dead
- Presence of fang marks at the bite site
- Absence of local or systemic signs and symptoms even after 12–24 h of bite (de Rezende et al., 1998)
- No laboratory evidence of envenomation
- Absence of venom antigens in the body fluids or tissue detected by standard ELISA method. Since there could be false positive or negative results, the venom assays should be interpreted in the light of clinical and other laboratory features of envenomation (Cook, 1992; Mead and Jelinek, 1996; de Rezende et al., 1998; White, 1998).
- Enzyme-linked Immuno sorbent Assay (ELISA) or Enzyme Immunoassay (EIA) helps in differentiating between a venomous snake bite from a non-venomous one by detecting the presence of venom in the blood or other body fluids at any time after bite. This could be of immense help in diagnosing the cases of dry bite in venomous snakes. This method could detect the venom is within three hours of bite (Theakston and Laing, 2014). Another investigative tool has been developed namely, Optical immunoassay (OIA), which is similar to EIA but based on a different principle (Dong et al., 2004). In Australia, a more sensitive Snake Venom Detection Kit (SVDK) has been developed but it's quite unaffordable to the developing countries that need it the most (Theakston and Laing, 2014). More research is on its way to enable the clinician to detect the envenomation immediately after bite and which is also cost effective.
- No anti-snake venom treatment or tourniquet application prior to hospitalisation (de Rezende et al., 1998)

3. Management of "dry bite"

- Patients who fulfil the diagnostic criteria of 'dry bite' should be hospitalised and observed closely for clinical and laboratory abnormalities indicating envenomation for at least 12–24 h. If the patient develops any evidence of envenomation during this period, he/she should be given anti snake venom therapy [antivenom] along with other supportive or symptomatic treatment (de Rezende et al., 1998; Herbert and Hayes, 2009).
- Anti-snake venom should never be given empirically or as a precaution, as risk of anaphylactic reactions outweighs the benefits (de Rezende et al., 1998; Herbert and Hayes, 2009).

4. Conclusions

Dry bite is a definitive and common occurrence in venomous snake bites and should be acknowledged while assessing the victim of a snake bite. More scientific work is needed to understand the patho-mechanics of 'dry bite 'in different snakes. The practice of administration a small dose of antivenom to every patient who complains of snake bite without any evidence of envenomation should be strongly discouraged and clinicians should take extra responsibility to educate the frightened and panicky patients and their relatives who sometimes claim to have seen the offending venomous snake, regarding the concept of the "dry bite" (Warrell, 2010). The health care authorities should be apprised of the risk of anti-venom reactions and persuaded to withdraw the recommendations of administration of anti-snake venom to every case of snake bite in the light of possible occurrence of "dry-bite". Acceptance of the clinical entity of 'dry bite' will go long way towards ending the practice of inappropriate antivenom use and will encourage conservation rather than misuse of costly and scarce anti venom.

Competing interests

None.

Conflicts of interest

No conflicts of interest included in the manuscript.

Ethical statement

Since this is a Review Article not involving any study on subjects Ethical clearance is not included.

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