Nigerian Research Journal of Engineering and Environmental Sciences 2(1) 2017 pp. 49-58

Nigerian Research Journal of Engineering and Environmental Sciences
Journal homepage: www.rjees.com

RJEES

Review Article

TOWARDS AUTOMATION OF A FIRST AID SYSTEM FOR SNAKE BITES: A SURVEY ON ORTHODOX FIRST AID TREATMENT METHODS FOR SNAKE BITE

***Apeh, S.T., Olaye, E. and Chiejine, P.**

Department of Computer Engineering, Faculty of Engineering, University of Benin, Benin City, Nigeria.
*apeh@uniben.edu

ARTICLE INFORMATION

Article history:
Received 16 March 2017
Revised 30 April 2017
Accepted 01 May 2017
Available online 01 June 2017

Keywords:
Snake bites
First aid methods
medical practitioners
survey
Automation

ABSTRACT

Snake bite and its widespread prevalence has not been fully acknowledged in Nigeria mostly due to under-documentation. This study has presented the available orthodox first aid methods along with their mode of application, strengths, weaknesses and level of recommendation based on review of the literature. These orthodox methods were critically reviewed and analyzed in order to set a basis for designing an automated system or a portable device for first aid treatment of snake bite. Automation can be based on the most recommended first aid method as safety is of utmost priority. Orthodox first aid methods include oral suction, mechanical suction, laceration, electrotherapy, cryotherapy, tourniquet placement, pressure immobilization as well as pressure bandaging. Of the sources that were critically reviewed, approximately seventy percent of them show that the most recommended orthodox first aid method is the pressure immobilization method.

1. INTRODUCTION

The healthcare system in Nigeria and the health status of Nigerians are in a poor state (Olayiwola, 1990; Aluko-Arowolo, 2005). As at 1997, Nigeria ranked 187th of the 191 member states covered by WHO (WHO, 2000). No improvements were recorded thirteen years later, instead it has grown worse. In Nigeria, over 70% of her inhabitants live in rural communities yet such areas have not attracted sufficient health facilities/projects that would substantially improve the health need of the dwellers (Ajilowo and Olujimi, 2007).

Few attempts have been made to quantify the burden of envenoming, and recent estimates all suffer from the lack of an objective and reproducible methodology (Kasturiratne et al., 2008).

Unfortunately, public health authorities, nationally and internationally, have given little attention to this problem, relegating snake bite envenoming to the category of a major neglected disease of the 21st century (Gutiérrez et al., 2006).

According to data presented to a WHO study group in January 2007 globally, over 1 million humans are bitten annually by venomous snakes. Hundreds of thousands of these persons have long-term injuries, while 20,000 to 100,000 die (Weinstein et al., 2009). Snake bite occurs frequently among rural people, especially those working in the fields (Omogbai et al., 2002). Populations in the rural areas experience high morbidity and mortality because of poor access to health services, which are often sub-optimal, and in some instances, a scarcity of anti-venom, which is the only specific treatment. A large number of these victims survive with permanent physical and psychological sequel (abnormality resulting from an injury) (Kasturiratne et al., 2008).

The four families of venomous snakes found in Nigeria are Viperidae, Elapidae, Colubridae and Atractaspididae (Del Brutto and Del Brutto, 2012). However, the medically most important species are: the Nigerian carpet viper (*Echis ocellatus*), the black-necked spitting cobra (*Naja nigricollis*), the gaboon viper (*Bitis gabonica*) and the puff adder (*Bitis arietans*), and they belong to the first two families mentioned above (Onyiriuka, 2011).

Snake bites in most parts of the tropics (especially the developing countries) are treated either by traditional healers at home or by orthodox practitioners in hospitals. Thus, many cases of snake bites are not reported to the hospital unless the traditional healer has failed to effect a cure and the victim survives to be taken to a hospital (Reid, 1957). Hospital records may therefore not fully account for the prevalence of snake bites in a community or country (Omogbai et al., 2002).

Although there exist orthodox first aid treatment techniques, they are not commonly available around communities and villages where snake bites commonly occur. Thus, requiring some level of expertise found among professionals to administer. Also, a nearby health institution is required, which could be distances apart from a point of envenomation from snake bites. There is therefore the need to develop a first aid system that is effectively in minimizing the spread of venom when a snake bite occurs until the victim gets to a nearby health institution for proper medical attention. The first aid system must also not necessarily require specialized know-how to be administered but something that any person, with minimal guidance, can effectively administer.

The aim of this paper is therefore to present a critical review of orthodox first aid techniques with a view to assembling requirements for building an effective and simple-to-use first aid treatment system that can be easily accessible and affordable in areas where snake bites are common.

2. ORTHODOX FIRST AID TECHNIQUES

There are several orthodox first aid treatment techniques identifiable from documented literature. These are discussed in this section

2.1. Oral Suction

This is done by cutting a small portion of the bitten area and sucking out the venom with the mouth. Even the use of leeches was employed as a method of suction during ancient times. In 1198, Maimonides, the sultan of Egypt's personal physician, described the making of incisions around, and distant to the bite with the application of oral suction to remove venom (Farrell, 1994). However, the classical cutting of "X-X" incisions over the bite can be traced to H.C. Yarrow, a U.S. army surgeon during the mid to late 1800s. After incising the area, the mouth was commonly used to withdraw the poison. Incision and suction were the standard of practice for a sustained period of time (Russell, 1983). Oral suction should be applied instantly so that the poison may not have time to circulate in the blood.

2.2. Mechanical Suction

One of the most popular suction devices, the Sawyer Extractor pump operates by applying approximately 1 atm of negative pressure directly over a fang puncture wound without making incisions. The extractor is a venom suction system that removes the venom from the victim's bloodstream. The manufacturer instructs that the device be applied within 3 minutes of the snake-bite and left in place for 30 to 60 minutes (Bush, 2004). To use the device requires selecting which of the four plastic cups best covers the bitten area, and attaching it to the pump. Then a simple push of the plunger with a thumb is applied and the extractor pump will quickly and effectively remove the snake venom from below the skin. The pump can be reused over and over again by simply cleaning the cups after each use (Meggs, 2012).

2.3. Laceration or Bleeding of Bite

Of the earlier known treatments for snake-bite, scarification by cutting through the fang punctures and associated areas, excision of the bite site and amputation were predominant practices. Nicander of Colophon, in the second century B.C., mentioned the use of snake teeth as the cutting tool for making scar-like incisions. Their use was believed of value because opening the wound allowed the escape of demons or venom responsible for the ill effects instilled by the serpent. These techniques were performed during ancient times in both Egyptian and Chinese cultures (Klauber, 1956; Russell, 1983).

2.4. Electrotherapy

At one time, it was theorized that electrical current may denature snake venom (Kanaan et al., 2015). The use of electric shock was first tested by Fontana as a static discharge for viper bite in 1787, and later in 1872 by Fayer using galvanism electrotherapy as a possible snake-bite treatment. Using a spark plug cable from an outboard boat motor running at half-throttle, snake bitten victims were given five, one-second high voltage, low amperage shocks. Consequently, the treatment became the panacea for treating venomous snake-bite. This also led to advertising and testimonial accounts in outdoor life magazine and other sportsman publications, promoting the use of stun guns and leading to the development of the special model for treating snake-bite (Trestrail, 2001).

2.5. Cryotherapy

Cryotherapy with ice or other cooling techniques is thought to reduce the spread of the snake venom (Kanaan et al., 2015). It is also thought to denature venom and retard its absorption (Blaylock, 2005). This method is carried out by applying ice on the snake bite marks.

2.6. Tourniquet Placement

A tourniquet is a tight constricting band which is applied to injured limbs to control bleeding in emergency situations. The tourniquet (a strong pliable material) is placed around the extremity, between the wound and the heart, 5 to 10 centimeters (2 to 4 inches) above the wound site. The purpose is to cut off the strong blood flow within arteries leaving the heart. This is achieved by using an elongated stick, scabbard or bayonet as a torsion device. A loop is made around the limb and tied with a square knot. The stick is passed under the loop and the tourniquet is tightened just enough to stop arterial bleeding. The free end of the stick is bound to the limb to keep it from unwinding (Army, 2002).

2.7. Pressure Bandaging

Pressure bandaging is thought to restrict the blood flow and progression of venom to systemic circulation by reducing lymphatic and venous return (Kanaan et al., 2015).

2.8. Pressure Immobilisation Method (PIM)

A newer technique is the pressure immobilization method (PIM). This advocates tying elasticated or crepe bandage around the limb including an integral splint, in the same way as for a sprain. This method was developed in Australia in the late 1970's and was advocated as a reliable technic to inhibit venom flow into the system (Ghosh, 2008).

3. ANALYSIS AND DISCUSSION OF FINDING

The first aid methods reviewed were analyzed and interpreted based on their levels of recommendation so as to pick out the most recommended that can be automated. Table 1 presents the various orthodox methods and their supposed effects on snake venom.

3.1. Analysis of Findings

Recommended first aid methods for snake-bite have changed through the years but have been generally directed towards removing the venom and preventing spread systemically.

3.1.1. Oral suction

It was only a few decades ago that incision and suction were recommended snake-bite first aid. However, concerns arose about injuries and infections caused when laypersons made incisions across fang marks and applied mouth suction (Bush, 2004). Also, one study and review article showed that mouth suction is not successful in removing venom in a "mock venom" human model, and the 0.04% to 2% of venom load extracted was clinically

insignificant (Alberts et al, 2004). Furthermore, oral suction can introduce bacteria into the wound and increase the potential for superinfection (Kanaan et al., 2015). Finally, oral suction may pose a risk to the caregiver by absorption of venom through the oral mucosa thus causing various kinds of infection (Riggs et al, 1987).

Table 1: Orthodox first aid methods

Method	Supposed Effect on Venom
Oral Suction	Removes venom or withdraws poison
Mechanical Suction	Removes the venom from the victim's bloodstream
Laceration	Allows venom to flow out
Electrotherapy	Denatures snake venom
Cryotherapy	Denatures snake venom and retards its absorption
Tourniquet placement	Cuts off strong blood flow
Pressure bandaging	Restricts the blood flow and progression of venom to systemic circulation

3.1.2. Mechanical suction

An experimental model showed that mechanical suction devices can increase localized tissue damage around the wound in the shape of the device, causing tissue necrosis and sloughing, resulting in tissue loss that prolonged healing by weeks (Kanaan et al., 2015). In a study by Alberts et al. (2004) to determine the percentage of mock venom recovered by the Sawyer extractor pump in a simulated snake-bite in human volunteers, mock venom was injected with a curved 16-gauge hypodermic needle 1 cm into the right lateral lower leg of eight supine male volunteers aged 28-51 years. The pump was applied after a three minute delay and the blood removed by suction was collected after an additional fifteen minutes. The envenomation load as measured by mean radioactivity in the leg after injection was 89,895 counts/min. The mean radioactivity found in the blood extracted in the fifteen minutes of suction was 38.5 counts/min, representing 0.04% (insignificant) of the envenomation load. The Sawyer extraction pump removed bloody fluids from the simulated snake-bite wounds but virtually no mock venom were removed. This suggests that suction is unlikely to be an effective treatment for reducing the total body venom burden after a venomous snake-bite (Alberts et al., 2004). Thus the extractor might make the envenomation worse by paradoxically increasing the amount of venom left in the wound (Bush, 2004). If a suction device is to be automated, a lot of considerations has to be made as damage is associated with the suction techniques.

3.1.3. Laceration

Laceration or bleeding the bite site to enlarge the wound to increase blood flow often results in increased tissue damage and local irritation and is without any proven benefit (Kanaan et al., 2015). However, cutting might result in the ease of a venom which acts locally i.e. on the muscles (myotoxic venoms). This is called debridement (surgical removal of dead tissue from a wound in order to prevent infection and promote healing).

3.1.4. Electrotherapy

Research demonstrated that electrotherapy is not useful for snake-bite treatment and is harmful to the patient (Kanaan et al., 2015). In controlled animal studies, electric shock

therapy has shown no effect. Venom was not inactivated using electric current from a commercial stun gun directly applied to a snake venom solution in an electrolysis cell. Electric shock treatment is not recommended and should not replace vacuum suction (Blackman and Dillon, 1992).

3.1.5. Cryotherapy

This technique has no proven benefit, and in extreme cases can result in increased localized tissue injury (Kanaan et al., 2015). Cryotherapy, including ice, ice water immersion, and cold sprays, is no longer recommended. Animal studies have shown ice to be effective at retaining venom at the inoculation site, but rapid venom dispersal following removal of the ice has produced shock. Exposure to cold produces vasoconstriction in already compromised tissues while prolonged exposure can result in gangrene, and the victim could require amputation. The American Red Cross and the Committee on Trauma of the American College of Surgeons recommend against its use (Blackman and Dillon, 1992).

3.1.6. Tourniquet placement

Tourniquets (either venous or arterial occluding tourniquets) can lead to ischemia (local anemia in a given body part), gangrene (localized death of living cells) lymphedema (swelling caused by lymph accumulating in the tissues in the affected areas), necrosis, and peripheral neuritis (inflammation of a nerve accompanied by pain), which can result in a higher amputation frequency or anti-venom requirements, and no studies have conclusively demonstrated tourniquets improve patient outcomes (Amaral et al,, 1998; Kasturiratne et al., 2008; Theakston, 1997). Traditional tight (arterial) tourniquets are not recommended. To be effective, these have to be applied around the upper part of the limb so tightly that the peripheral pulse gets occluded. This method can be extremely painful and very dangerous if the tourniquet is left on for too long (more than about 40 minutes), as the limb might be damaged by ischemia.

3.1.7. Pressure bandaging

Clinical evidence for pressure bandaging with elastic or cohesive bandaging is limited. One study using a porcine (an omnivorous animal) model with a lethal dose of venom showed pressure immobilization increased intra-compartmental pressure after envenomation and delayed mortality (Bush et al., 2004). Only when treating life-threatening snake-bites containing neurotoxic venom does evidence support containing the venom with pressure bandaging (Currie et al, 2008). One animal study demonstrated lethal hyperkalemia (abnormally high levels of potassium in the circulating blood) when the pressure wrap was removed (Meggs et al, 2010). Furthermore, two studies indicated that physicians and laypeople rarely apply pressure bandaging correctly (i.e. they either apply too much pressure which completely stops blood flow or too little pressure which defeats the purpose of pressure bandaging) (Canale et al., 2009; Norris et al., 2005), and a third showed that even after training, practitioners were still unsuccessful at effective immobilization in cases of simulated snake-bites (Simpson et al., 2008).

3.1.8. Pressure immobilisation method

A constrictive bandage to impede lymphatic and capillary is used to impede venom flow. A constrictive bandage properly applied to impede lymphatic and capillary flow, together with limb immobilization, is shown to be effective in the field management of human elapid envenomation (Pearn et al, 1981).

3.2. Discussion of Findings

Most of the methods reviewed were found improperly applied by most persons hence increasing the rate of venom flow and reducing the chances of survival. For this reason, automating an effective first aid method becomes necessary. However, before automation can be achieved, a lot must be taken into consideration. It would be a waste of time to automate a first aid method that when applied will cause more harm than good, as in laceration or electricity methods. Table 2 presents findings on the suitability of snake bite management methods for automation. It provides a high/low scale for suitability for automation and safety level.

Table 2: Suitability of Snake bite management methods for automation

S/N	Method	Automation	Safety level	Challenges
1	Suction	High	Low	Wrong first-aid practice
2	Laceration	Low	Low	Wrong first-aid practice
3	Electrotherapy	High	Low	Wrong first-aid practice
4	Cryotherapy	Low	High	Non availability of ice
5	Tourniquet placement	High	Low	Wrong first-aid practice
6	Pressure bandaging	High	High	Non uniform bandage pressure

The levels, namely "High" and "Low" in Table 2 are subjective scales to assess the degree of automation possible with the selected methods from an engineering perspective. The scales are also used to assess the degree of effectiveness and safety based on the judgment of medical experts after the proposed automation methods were described to them. In analyzing the various first aid methods, the most recommended as documented in literature is the pressure immobilization method (PIM). It can also be seen as an improved tourniquet method. The pressure immobilization method (PIM) can be automated if the above listed points are taken into consideration. This can be designed in combination with the cryotherapy or cooling method. Although there is a drawback in using this cooling method, the system can be designed to bypass it. That is, the user should be advised not to take of the device until a medical personnel is available to offer proper diagnosis and treatment.

4. CONCLUSION

The most recommended orthodox first aid method based on analysis of the findings is the pressure immobilization method (PIM). This technique can be automated as a system that applies differential pressure on the snake bite region. It can also incorporate a cooling mechanism in it.

5. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

REFERENCES

Ajilowo, J. and Olujimi, B. (2007). Accessibility of the Rural Dwellers to Healthcare Facilities in Nigeria: The Owo experience. *Pakistan Journal of Social Sciences*, 4(1), pp, 44-55.

Alberts, M. B., Shalit, M. and LoGalbo, F. (2004). Suction for venomous snakebite: a study of "mock venom" extraction in a human model. *Annals of emergency medicine*, 43(2), pp. 181-186.

Aluko-Arowolo, S. (2005). Equity in Health and Federal Character Policy: A Study in Rural-Urban Dichotomy. *Babcock Journal of Management and Social Sciences*, 4(1), pp. 38-47.

Amaral, C.F., Campolina, D., Dias, M.B., Bueno, C.M. and Rezende, N.A. (1998). Tourniquet ineffectiveness to reduce the severity of envenoming after Crotalus durissus snake bite in Belo Horizonte, Minas Gerais, Brazil. *Toxicon*, 36(5), pp. 805-808.

Blackman, J.R. and Dillon, S. (1992). Venomous snakebite: past, present, and future treatment options. *The Journal of the American Board of Family Practice*, 5(4), pp. 399-405.

Blaylock, R. (2005). The identification and syndromic management of snakebite in South Africa. *South African Family Practice*, 47(9), pp. 48-53.

Bush, S.P. (2004). Snakebite suction devices don't remove venom: they just suck. *Annals of emergency medicine*, 43(2), pp. 187-188.

Bush, S.P., Green, S.M., Laack, T.A., Hayes, W.K., Cardwell, M.D. and Tanen, D.A. (2004). Pressure immobilization delays mortality and increases intracompartmental pressure after artificial intramuscular rattlesnake envenomation in a porcine model. *Annals of emergency medicine*, 44(6), pp. 599-604.

Canale, E., Isbister, G.K. and Currie, B.J. (2009). Investigating pressure bandaging for snakebite in a simulated setting: bandage type, training and the effect of transport. *Emergency Medicine Australasia*, 21(3), pp. 184-190.

Currie, B. J., Canale, E., and Isbister, G. K. (2008). Effectiveness of pressure-immobilization first aid for snakebite requires further study. *Emergency Medicine Australasia*, 20(3), pp. 267-270.

Del Brutto, O., and Del Brutto, V. (2012). Neurological complications of venomous snake bites: a review". *Acta Neurologica Scandinavica*, 125(6), pp. 363-372.

Farrell, M. (1994). Poisons and poisoners: An encyclopedia of homicidal poisonings: Bantam books.

Ghosh, S. (2008). Management of Snake Bite-An Update. *Medicine*, 18, pp. 691-696.

Gutiérrez, J. M., Theakston, R. D. G. and Warrell, D. A. (2006). Confronting the neglected problem of snake bite envenoming: the need for a global partnership. *PLoS Med*, 3(6), pp. 01-05.

Habib, A. G. (2013). Public health aspects of snakebite care in West Africa: perspectives from Nigeria. *Journal of Venomous Animals and Toxins including Tropical Diseases*, 19, pp. 1-14.

Kanaan, N. C., Ray, J., Stewart, M., Russell, K. W., Fuller, M., Bush, S. P. and Weinstein, S.A. (2015). Wilderness Medical Society Practice Guidelines for the Treatment of Pitviper Envenomations in the United States and Canada. *Wilderness & environmental medicine*, 26(4), pp. 472-487.

Kasturiratne, A., Wickremasinghe, A. R., de Silva, N., Gunawardena, N. K., Pathmeswaran, A., Premaratna, R. and de Silva, H. J. (2008). The global burden of snakebite: a literature analysis and modelling based on regional estimates of envenoming and deaths. *PLoS Med*, 5(11), pp.1592- 1604.

Klauber, L. M. (1956). Rattlesnakes" University of California Press, (1).

Meggs, W. (2012). Snake Bite First Aid: Interest of Experimental Studies". Paper presented at the Clinical Toxicology.

Meggs, W. J., Courtney, C., O'Rourke, D., and Brewer, K. L. (2010). Pilot studies of pressure-immobilization bandages for rattlesnake envenomations. *Clinical Toxicology*, 48(1), pp. 61-63.

Norris, R. L., Ngo, J., Nolan, K., and Hooker, G. (2005). Physicians and lay people are unable to apply pressure immobilization properly in a simulated snakebite scenario. *Wilderness & environmental medicine*, 16(1), pp.16-21.

Olayiwola, L. (1990). A Study of the Adequacy of Infrastructural Facilities in Rural Areas of Oranmiyan Local Government. Unpublished Ph. D. Thesis, Obafemi Awolowo University, Ile-Ife.

Omogbai, E. K., Nworgu, Z. A., Imhafidon, M. A., Ikpeme, A. A., Ojo, D. O., and Nwako, C. N. (2002). "Snake bites in Nigeria: A study of the prevalence and treatment in Benin City. *Tropical Journal of Pharmaceutical Research*, 1(1), pp.39-44.

Onyiriuka, A. N. (2011). Snake-bite poisoning in childhood: approach to diagnosis and management. *Paediatrics Today*, 8(1), pp.11-21.

Pearn, J., Morrison, J., Charles, N., and Muir, V. (1981). First-aid for snake-bite: efficacy of a constrictive bandage with limb immobilization in the management of human envenomation. *The Medical journal of Australia*, 2(6), pp. 293-295.

Reid, L. K. (1957). Snake bite. A survey of fishing village in North-West Malaya. *Brazillian Medical Journal*, 2, pp. 1266-1272.

Riggs, B., Smilkstein, M., Kulig, K., and RUMACK, B. (1987). "Rattlesnake envenomation with massive oropharyngeal edema following incision and suction". Paper Presented At The American Association for Clinical Toxicology (AACT)/ American Association of Poison Control Centers (AAPCC)/ Advanced Board of Medical Toxicology (ABMT)/ Canadian Association of poison control centres (CAPCC) Annual Scientific Meeting.

Russell, F. (1983). Snake venoms poisoning. Scholium International Inc, Great Neck.

Simpson, I. D., Tanwar, P., Andrade, C., Kochar, D., and Norris, R. L. (2008). The Ebbinghaus retention curve: training does not increase the ability to apply pressure immobilisation in simulated snake bite—implications for snake bite first aid in the developing world. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 102(5), pp. 451-459.

Theakston, R. (1997). An objective approach to antivenom therapy and assessment of first aid measures in snake bite. *Annals of Tropical Medicine and Parasitology*, 91(7), pp. 857-866.

Trestrail, J. H. (2001). Toxicological History Society Newsletter. 11(2), pp. 5-9.

Weinstein, S., Dart, R., Staples, A. and White, J. (2009). Envenomations: an overview of clinical toxinology for the primary care physician. *American Family Physician*, 80(8), pp. 793-802.

World Health Organization (2000). The world health report 2000: health systems: improving performance.