HHS Public Access

Author manuscript

Int J Clin Res Trials. Author manuscript; available in PMC 2019 September 16.

Published in final edited form as:

Int J Clin Res Trials. 2019 ; 4: . doi:10.15344/2456-8007/2019/133.

Cerebrovascular Accident and Snake Envenomation: A Scoping Study

Mohammed Al-Sadawi[1], **Maliheh Mohamadpour**[1], **Angelina Zhyvotovska**[1], **Tahir Ahmad**[1,2], **Joshua Schechter**[2], **Yasmin Soliman**[1], **Samy I. McFarlane**[1,*]

[1]Department of Internal Medicine, Division of Cardiovascular Disease, State University of New York, Downstate Medical Center, Brooklyn, NY 11203, USA

[2]Department of Emergency Medicine State University of New York, Downstate Medical Center, Brooklyn, New York, USA

Abstract

Background: Snake envenomation is associated with serious complications including infections, bleeding and, in rare occasions, thrombosis. Previous work by our group examined the association of snakebite and acute myocardial infarction. In this systematic review we aim to assess the clinical characteristics and outcomes of acute cerebrovascular accidents that are reported to be extremely rare complications of snake envenomation.

Methods: We performed a literature search for reports on stroke associated with snake envenomation between Jan 1995 to Oct 2018, and summarized their characteristics.

Results: Eighty-three published cases were reviewed. 66.3% of the cases were younger than 50 years of age. The mean time for the onset of the symptoms is 23.8±10.9 hours after exposure. 77.1% of the cases found to have ischemic stroke, 20.5% with intra-cranial hemorrhage and both infarction and hemorrhage in 2.4%. Mortality was reported in 16.9% with mean time between onset of the symptoms and death is 4.2 days.

Conclusion: Stroke secondary to snake envenomation is a rare but serious complication. Once stroke is suspected, initiating appropriate management is crucial in reducing morbidity and mortality associated with this potentially fatal complication of snake envenomation.

Keywords

Snake Envenomation; Stroke; Cerebrovascular accident

[*]**Corresponding Author:** Prof. Samy I. McFarlane, Divisions of Cardiovascular Disease,and Endocrinology, Department of Internal Medicine, State University of New York, Downstate Medical Center, Brooklyn, New York,11203, USA, Tel: 718-270-6707, Fax: 718-270-4488; smcfarlane@downstate.edu.

Competing Interests

The authors declare no competing interests.

Introduction

Snake bite is one of the causes of stroke that has been reported less frequently. According to WHO, annual rate of snake bites have been estimated 5.4 million worldwide. Proximately 81000–138000 deaths have been reported annually. Most common affected population is among young adults and children in Africa, Asia and Latin America [1]. According to Center of Disease Control (CDC), annual rate of snake bite in the United States is 7,000–8,000 with about 5 deaths. The most common species in the United States reported by Central of Disease Control (CDC) includes rattlesnakes, copperheads, cottonmouths/water moccasins, and coral snakes [2]. In a Sri Lanka case series, the incidence of post-bite ischemic stroke was reported 9 in 500 bites [3].

Different Snake venoms contain different types of enzymes such as phospholipase A2, acetylcholinesterase, hyaluronidase, and metalloproteinases; such enzymes that have either direct neurotoxic or procoagulant or anticoagulation effects [4]. Therefore, These enzymes predisposing for causing either cerebral infarction due to cerebral hypoperfusion (watershed infarct), thrombotic occlusion of large vessels, vasculitis, consumption coagulopathy, or cardiogenic brain embolism; or hemorrhagic stroke [5,6].

Depending on the enzyme content in the venom, the pro-coagulation versus anticoagulation activities can be prominent. For Instance, viper and colubrid venoms contain metalloproteinases, serine proteases, and C-type lentins with either agonist or antagonist platelet aggregation activity while the venom of elapids contains phospholipase A2 and three-finger proteins, which acts as an neurotoxins in neuromuscular junction [7].

There are few case series reporting snakebite related strokes with detailed information regarding the type of the venom and the type of stroke. Previous work by our group examined the association of snakebite and acute myocardial infarction [8]. In this study, we reviewed different case reports and series of snake envenomation associated with stroke and the outcome.

Methods

On October 2018, a systematic search was conducted using PubMed and Google Scholar to review case reports about stroke caused by snake envenomation from January 1995 to October 2018. Studies that listed the keywords “snake, envenomation, stroke, cerebrovascular accidents” were used to identify case reports of stroke associated with snake envenomation. The reference list of each report was checked for additional cases. Data reviewed included demographic data, cardiovascular risk factors, snake species, computed tomography of the head, magnetic resonance of the head, time of presentation, complications, management, and outcome.

Results

83 cases were identified (Table 1) [9–79]. The patients were in the age group of 5 to 80 years and the mean age was 40 ± 17.5 years, median age was 40 years and 66.3% of the cases were younger than 50 years of age. 68.7% of the cases were reported for males and 31.3%

for females. Diabetes Mellites and hypertension were reported only in 2 cases (2.4%). Snake Species are represented in (Figure 1); however, about 30% of the cases did not mention snake species. 30% of the cases reported with *Daboia, Russell's* viper, species. 83.1% of the cases were bitten in their legs and 16.9% were bitten in hands. All the cases were managed by anti-snake venom, in 27.7% of the cases the symptoms started after receiving anti-snake venom. 19.3% of the cases also treated with antiplatelet and 3.6% were treated with craniotomy. The mean time for the onset of the symptoms is 23.8±10.9 hours after exposure. 77.1% of the cases found to have ischemic stroke, 20.5% with intra-cranial hemorrhage and both infarction and stroke in 2.4%.

Complications were reported in many cases: Altered mental status necessities intubation in 36.1% of the cases, acute kidney injury was reported in 12.2%, pulmonary edema in 3.6%, myocarditis in 1.2% and endocarditis in 1.2%. The outcome of the cases showed full recovery in 26.5% with mean time needed for recovery 88.9 days. Mortality was reported in 16.9% mainly due to complication of stroke with mean time between onset of the symptoms and death is 4.2 days.

Discussion

Venomous snakes can cause stroke due to either their neurotoxic or hemotoxic enzymes [4]. However, type of stroke either hemorrhagic or ischemic depends on the venom enzyme-make up in each different snake species.

Ischemic strokes were 77.1% of the cases while ICH were 20.5%. As reported, the most common species were Russell's vipers with higher incidence of ischemic stroke than intracranial hemorrhage (ICH). Whereas, reportedly *Bothrops* species were the second most common venoms to be reported with significantly more propensity towards ICH than ischemic stroke [3]. Most of the cases exposed to snake bites are young males <50 years old. Mortality rate was higher among *Russell's* vipers; however, *Russell's* vipers were the most commonly reported bite. There was single report of bite by Horned viper and *Pseudonaja textilis* with ICH; *Cerastes* and *Deinagkistrodon* envenomation were associated with large infarcts [29,74,32,66].

The venom of *Bothrops* species contains metalloproteinases, type of hemotoxin that can cause hemolysis, thrombocytopenia, disseminated intravascular coagulation [76,77]. Among *Borthrops*, ICH was frequently reported in *jararacussu, atrox, marajoensis* species and infarcts was reported for *lanceolatu* species. Most of the patient who had bites were young and no comorbidity or risk factor for either hemorrhagic or ischemic stroke except 2% who had history of diabetesmellitus or hypertension.

Mortality was more common among those who either arrived in coma or required intubation due to AMS during the course of hospitalization. Death happened within the first 4.2 days after the exposure. Risk of mortality was amplified by ICH, bilateral extensive cerebral, cerebellar infarction, mass effect, or post circulation occlusion.

However, all the cases received anti-venom once they sought medical care after exposure; while mean time for the onset of symptoms was 23.8 h after envenomation. In 27.7% of the

cases symptoms started even after receiving antivenom which indicates the potency of the venom in causing stroke and the importance of early administration of anti-venom serum with consideration of other adjutant therapies. There are some animal studies indicating the critical and time sensitive usage of metalloproteinase inhibitors and antivenom would be the best approach to reduce hemorrhagic stroke after *Bothrops* species envenoming [78]. Studies have shown that single individual fractions of different venoms have failed to be lethal to mice in some studies even after 48 h, whereas a corresponding concentration of whole crude venom have been sufficiently lethal within 10 min. Synergistic action of venom component is important for designing more effective antivenoms [79]. In figure 2, we summarized the postulated mechanisms for cerebrovascular accidents following a snake envenomation.

Limited access to antivenom and also lack of awareness for seeking medical management shortly after snakebite to reduce the chance of cerebrovascular events and the other complications mainly in developing countries is an alarming medical emergency to be addressed. Therefore, WHO considered snake envenomation as category A neglected tropical diseases to maximize the efforts facing its complication [80].

Conclusion

Stroke is a rare but rather serious complication of snake envenomation that is associated with high mortality rate. Further research is needed to elucidate the mechanisms of stroke in the context of snakebites thus paving the way for the development of specific therapeutic interventions. However, early administration of anti-venom serum with consideration of other adjutant therapies is crucial in snakebites in order to reduce the associated complications including strokes.

Acknowledgements

This work is supported, in part, by the efforts of Dr. Moro O. Salifu M.D., M.P.H., M.B.A., M.A.C.P., Professor and Chairman of Medicine through NIH Grant number S21MD012474.

References

1. World Health Organization (2018) Facts sheets: WHO Snakebite envenoming.
2. Center of Disease Control.
3. Thomas L, Tyburn B, Ketterle J, Biao T, Mehdaoui H, et al. (1998) Prognostic significance of clinical grading of patients envenomed by Bothrops lanceolatus in Martinique. Soc Trop Med Hyg 92: 542–545.
4. Warrell DA (1996) Animal toxins. In: Cook GC, ed. Manson's tropical diseases. 20th ed London: Saunders.
5. Del Brutto OH (2013) Neurological effects of venomous bites and stings: snakes, spiders, and scorpions. HandbClin Neurol 114: 349–368.
6. Panicker JN, Madhusudanan S (2000) Cerebral infarction in a young male following viper envenomation. J Assoc Physicians India 48: 744–745. [PubMed: 11273516]
7. Del Brutto OH, Del Brutto VJ (2012) Neurological complications of venomous snake bites: a review. Acta Neurol Scand 125: 363–372. [PubMed: 21999367]
8. Samy I McFarlane (2018) Myocardial Infarction after Snakebite Envenomation: A Scoping Study. SF J Cardiol 2:3.

9. Sahoo AK, Sriramka B (2018) Acute Reversible Ischemic Stroke after Snake Bite. Indian J Crit Care Med 22: 611–612. [PubMed: 30186014]
10. Sahoo LK, Mallick AK, Mohanty G, Swain KP, Biswal NR, et al. (2018) A Rare Case of Stroke Due to Multiple Ischemic Infarctions following Russell's Viper Envenomation. Med J DY Patil Vidyapeeth 11: 57–58.
11. Kutiyal AS, Malik C, Hyanki G (2018) Locked-in syndrome post snake bite: a rare presentation. Trop Doct 48: 68–69. [PubMed: 28835176]
12. Pothukuchi VK, Chepuri VR, Natta K, Madigani N, Kumar A, et al. (2017) A rare case report of Russell's viper snakebite with ischemic stroke. Hong Kong Journal of Emergency Medicine 25: 95–97.
13. Bakare AK, Wahab K, Ilesanmi O, Sanya E (2018) Intraparenchymal Intracerebral Hemorrhage Complicating Venomous Snakebite in Nigeria: A Case Report. Neurology 90: 6.235.
14. Pothukuchi VK, Kumar A, Teja C, Verma A (2017) Rare Case Series of Ischemic Stroke Following Russell's Viper Snake Bite in India. Acta Med Indones 49: 343–346. [PubMed: 29348385]
15. Namal Rathnayaka RM, Kularatne SA, Kumarasinghe KD, Ranaweera J, Nishanthi Ranathunga PE, et al. (2017) Ischemic brain infarcts and intracranial haemorrhages following Russell's viper (Daboiarusselii) bite in Sri Lanka. Toxicon 125: 70–73. [PubMed: 27871786]
16. Delgado ABT, Gondim CCVL, Reichert LP, da Silva PHV, Souza RMDCE, et al. (2017) Hemorrhagic stroke secondary to Bothrops spp. venom: A case report. Toxicon 132: 6–8. [PubMed: 28377113]
17. Silva de Oliveira S, Freitas-de-Sousa LA, Alves EC, de Lima Ferreira LC, da Silva IM, et al. (2017) Fatal stroke after Bothrops snakebite in the Amazonas state, Brazil: A case report. Toxicon 138: 102–106. [PubMed: 28842354]
18. Janardanaaithala (2017) Thrombotic stroke following viper bite. University Journal of Medicine and Medical Sciences.
19. Swati AC, Arjun MD, Piyush AR (2017) Rare Snake Bite Sequelae: Intracerebral Haemorrhage with Cerebellar Infarction. International Journal of Contemporary Medical Researc.
20. Paul R, Sasane S (2017) Rare Ischemic Stroke Presentation after Viper Bite-A Case Report. IntJ Neurology Res.
21. Krishna PV, Ahmed S, Reddy KVN (2017) Ischemic stroke consequent to snake bite. J NTR Univ Health Sci 6: 192–193.
22. Pal J, Mondal S, Sinha D, Ete T, Chakraborty A, et al. (2014) Cerebral infarction: an unusual manifestation of viper snake bite. JRMS 2: 3.
23. Thomas A, Varghese P, Jalal MJA (2017) Intracerebral Hemorrhage: A Rare Snake Bite Sequelae. Indian Journal of Neurosurgery 6: 27–30.
24. Cañas CA (2016) Brainstem ischemic stroke after to Bothropsatrox snakebite, Toxicon 120: 124–127. [PubMed: 27527269]
25. Silveira GG, Machado CR, Tuyama M, Lima MA (2016) Intracranial Bleeding Following Bothrops sp. Snakebite. Neurologist 21: 11–12. [PubMed: 26703003]
26. Ajit D, Kumar SG (2016) Acute Cerebral Infarct on Evolution in Middle Cerebral Artery Following Viper Snake Bite. JSR.
27. Bhojaraja M, Prabhu MM, Stanley W, Sanket S, Marimuthu VKN, et al. (2016) Snake bite: An unusual cause of ischaemic stroke. AMJ 9: 138–141.
28. Jeyaraj M (2016) An interesting case of Ischemic stroke following snake bite. University Journal of Medicine and Medical Sciences 2: 1.
29. Ghezala HB, Snouda S (2015) Accident vasculaire cerebral hémorragique mortel suite à une envenimation par une vipère à corne en Tunisie. Hemorrhagic stroke following a fatal envenomation by a horned viper in Tunisia. Pan Afr Med J 21: 156. [PubMed: 26327993]
30. Pardal Pinheiro, Silva Santos, Gadelha. Hemorrhagic stroke in children caused by Bothropsmarajoensis envenoming: a case report. Journal of Venomous Animals and Toxins Including Tropical Diseases.
31. Paul G, Paul B, Puri S (2014) Snake bite and stroke: Our experience of two cases. Indian J Crit Care Med 18: 257–258. [PubMed: 24872661]

32. Rebahi H, Nejmi H, Abouelhassan T, Hasni K, Samkaoui MA, et al. (2014) Severe Envenomation by Cerastescerastes Viper: An Unusual Mechanism of Acute Ischemic Stroke. J Stroke Cerebrovasc Dis 23: 169–172. [PubMed: 22964421]
33. Bush SP, Mooy GG, Phan TH (2014) Catastrophic Acute Ischemic Stroke After Crotalidae Polyvalent Immune Fab (Ovine)-Treated Rattlesnake Envenomation. Wilderness Environ Med 25: 198–203. [PubMed: 24864067]
34. Mahale R, Mehta A, Javali M, Srinivasa R (2014) A case of bilateral occipital lobe infarcts following Indian tree viper bite. J Stroke 16: 205–207. [PubMed: 25328881]
35. Gopalan S, Ramadurai S, Bharathi L, Arthur P (2014) Ischaemic stroke with internal carotid artery occlusion following viper bite: A case report. Neurology Asia 19: 191–193.
36. Chandrashekar Anikethana GV, Kalinga BE (2012) Viper Bite Presenting as Acute Ischemic Stroke. IJSR.
37. Kumar N, Mukherjee S, Patel MP, Shah KB, Kumar S, et al. (2014) A case of saw scale viper snake bite presenting as intraparenchymal haemorrhage: case report. Int J Health Sci Res 4: 333–337.
38. Vale TC, Leite AF, Hora PR, Coury MI, Silva RC, et al. (2013) Bilateral posterior circulation stroke secondary to a crotalid envenomation: case report. Rev Soc Bras Med Trop 46: 255–256. [PubMed: 23740059]
39. Bhatt A, Menon AA, Bhat R, Ramamoorthi K (2013) Myocarditis along with acute ischaemic cerebellar, pontine and lacunar infarction following viper bite. BMJ Case Rep.
40. Das SK, Khaskil S, Mukhopadhyay S, Chakrabarti S (2013) A patient of Russell's viper envenomation presenting with cortical venous thrombosis: An extremely uncommon presentation. J Postgrad Med 59: 235–236. [PubMed: 24029207]
41. Aissaoui Hammi, Chkoura (2013) Bull. Soc Pathol Exot 106: 163.
42. Saha K, Saha D, Mondal RRS, Ranjit P Sarkar S, et al. (2013) Cerebral Infarct with Septicemia: An unusual presentation of Snake Bite. IJRRMS.
43. Ittyachen AM, Jose MB (2012) Thalamic infarction following a Russell's viper bite. Southeast Asian J Trop Med Public Health 43: 1201–1204. [PubMed: 23431827]
44. Chani Abouzahir, Haimeur DrissiKamili, Mion, et al. Accident vasculairecérébralischémique à la suite d'uneenvenimationvipérine grave au Maroc, traitée par un antivenin inadapté. AnnalesFrançaisesd'Anesthésieet de Réanimation, 31: 82–85.
45. Jeevagan V, Chang T, Gnanathasan CA (2012) Acute ischemic stroke following Hump-nosed viper envenoming; first authenticated case. Thromb 10: 21.
46. Gupta S, Tewari A, Nair V (2012) Cerebellar infarct with neurogenic pulmonary edema following viper bite. J Neurosci Rural Pract 3: 74–76. [PubMed: 22346200]
47. Gouda S, Pandit V, Seshadri S, Valsalan R, Vikas M, et al. (2011) Posterior circulation ischemic stroke following Russell's viper envenomation. Ann Indian Acad Neurol 14: 301–303. [PubMed: 22346023]
48. Deepu D, Hrishikesh S, Suma MT, Zoya V (2011) Posterior fossa infarct following Viper bite: a paradox. J Venom Anim Toxins incl Trop Dis 17: 358–360.
49. Sathishkumar (2017). JMSCR.
50. Hsaini Y, Satte A, Balkhi H, Karouache A, Bourezza A, et al. (2010) Infarctus cerebral secondaire à une morsure de vipère. Annales Françaisesd' Anesthésieet de Réanimation 29: 315–316.
51. Machado AS, Barbosa FB, Mello GS, Pardal PPO (2010) Hemorrhagic stroke related to snakebite by bothrops genus: a case report. Rev Soc Bras Med Trop 43: 602–604. [PubMed: 21085881]
52. Tungpakorn N (2010) Unusual visual loss after snakebite. J Venom Anim Toxins incl Trop Dis 16: 519–523.
53. Narang SK, Paleti S, Azeez Asad MA, Samina T (2009) Acute ischemic infarct in the middle cerebral artery territory following a Russell's viper bite. Neurol India 57: 479–480. [PubMed: 19770552]
54. Hoskote SS, Iyer VR, Kothari VM, Sanghvi DA (2009) Bilateral anterior cerebral artery infarction following viper bite. J Assoc Physicians India 57: 67–69. [PubMed: 19753762]

55. Gawarammana I, Mendis S, Jeganathan K (2009) Acute ischemic strokes due to bites by Daboiarusselii in Sri Lanka-First authenticated case series. Toxicon 54: 421–428. [PubMed: 19463846]
56. Mugundhan K, Thruvarutchelvan K, Sivakumar S (2008) Posterior circulation stroke in a young male following snake bite. J Assoc Physicians India 56: 713–714. [PubMed: 19086359]
57. Prakash S, Mathew C, Bhagat S (2008) Locked-in Syndrome in Snakebite. J Assoc Physicians India 56: 121–122. [PubMed: 18472515]
58. Santos-Soares PC, Bacellar A, Povoas HP, Brito AF, Santana DL, et al. (2007) Stroke and snakebite: case report. Arq Neuropsiquiatr 65: 341–344. [PubMed: 17607441]
59. Das (2007) Acute ischemic stroke in a Young Girl After Viper Bite. OPJ.
60. Thomas L, Chausson N, Uzan J, Kaidomar S, Vignes R, et al. (2006) Thrombotic stroke following snake bites by the “Fer-de-Lance” Bothropslanceolatus in Martinique despite antivenom treatment: A report of three recent cases. Toxicon 48: 23–28. [PubMed: 16750232]
61. Merle H, Donnio A, Ayeboua L, Plumelle Y, Smadja D, et al. (2005) Occipital Infarction Releaved by Quadrantanopsia Following Snakebite by BothropsLanceolatus. Am J Trop Med Hyg 73: 583–585. [PubMed: 16172485]
62. Bhalla A, Jain AP, Banait S, Jajoo UN, Kalantri SP, et al. (2004) Central retinal artery occlusion: an unusual complication of snakebite. J Venom Anim Toxins incl Trop Dis 10: 311–314.
63. Lee Hong, Kim Kim, Ko (2004) Cerebral Infarction Following Snakebite. J Korean SocEmerg Med 15: 420–425.
64. Bartholdi D, Selic C, Meier J, Jung HH (2004) Viper snakebite causing symptomatic intracerebral haemorrhage. J Neurol 251: 889–891. [PubMed: 15258798]
65. Boviatsis EJ, Kouyialis AT, Papatheodorou G, Gavra M, Korfias S, et al. (2003) Multiple Hemorrhagic Brain Infarcts After Viper envenomation. Am J Trop Med Hyg 68: 253–257. [PubMed: 12641421]
66. Zhang T, Wang Y, Ye P, Liu J, Cheng Y, et al. (2018) Three-dimensional computed tomography reconstructive diagnosis of snakebite-induced cerebral infarction. J Xray Sci Technol 26: 165–169. [PubMed: 29480239]
67. Hung DZ, Wu ML, Deng JF, Yang DY, Lin-Shiau SY, et al. (2002) Multiple Thrombotic Occlusions of Vessels after Russell’s Viper Envenoming. Pharmacol Toxicol 91: 106–110. [PubMed: 12427109]
68. Diaz (2003) Infarto cerebral y accidenteofídico. Acta Neurol Colomb 19: 75–79.
69. Numeric P, Moravie V, Didier M, Chatot-Henry D, Cirille S et al. (2002) Multiple cerebral infarctions following a snakebite by Bothrops caribbaeus. Am J Trop Med Hyg 67: 287–288. [PubMed: 12408668]
70. Pinho MAO, Burdmann EA (2001) Fatal Cerebral Hemorrhage and acute renal failure After Young Bothrops Jararcussus snake bite. Renal Failure 23: 269–277. [PubMed: 11417959]
71. Lee BC, Hwang SH, Bae JC, Kwon SB, et al. (2001) Brainstem infarction following Korean viper bite. Neurology 56: 1244–1245. [PubMed: 11342702]
72. Panicker JN, Madhusudanan S (2000) Cerebral infarction in a young male following viper envenomation. J Assoc Physicians India 48: 744–745. [PubMed: 11273516]
73. Singh S, Dass A, Jain S, Varma S, Bannerjee AK, et al. (1998) Fatal Non-Bacterial Thrombotic Endocarditis Following Viperine Bite. Intern Med 37: 342–344. [PubMed: 9617877]
74. Midyett FA (1998) Neuroradiologic findings in brown snake envenomation: computed tomography demonstration. Australas Radiol 42: 248–249. [PubMed: 9727257]
75. Cole M (1996) Cerebral Infarct After Rattlesnake Bite. Arch Neurol 53: 957–958. [PubMed: 8859055]
76. Rucavado A, Soto M, Kamiguti AS, Theakston RD, Fox JW, et al. Characterization of aspercetin, a platelet aggregating component from the venom of the snake Bothrops asper which induces thrombocytopenia and potentiates metalloproteinase-induced hemorrhage. Thromb Haemost 85: 710–715. [PubMed: 11341509]
77. Kamiguti AS, Cardoso JL (1989) Haemostatic changes caused by the venoms of South American snakes. Toxicon 27: 955–963. [PubMed: 2678605]

78. Gutierrez JM, Leon G, Tojas G, Lomonte B, Rucavado A, et al. (1989) Neutralization of local tissue damage induced by Bothrops asper (terciopelo) snake venom. Toxicon 36: 1529–1538.

79. Xiong S, Huang C (2018) Synergistic strategies of predominant toxins in snake venoms. Toxicol Lett 287: 142–154. [PubMed: 29428543]

80. Lancet The (2007) Snake-bite envenoming: a priority neglected tropical disease. Lancet 390: 2.

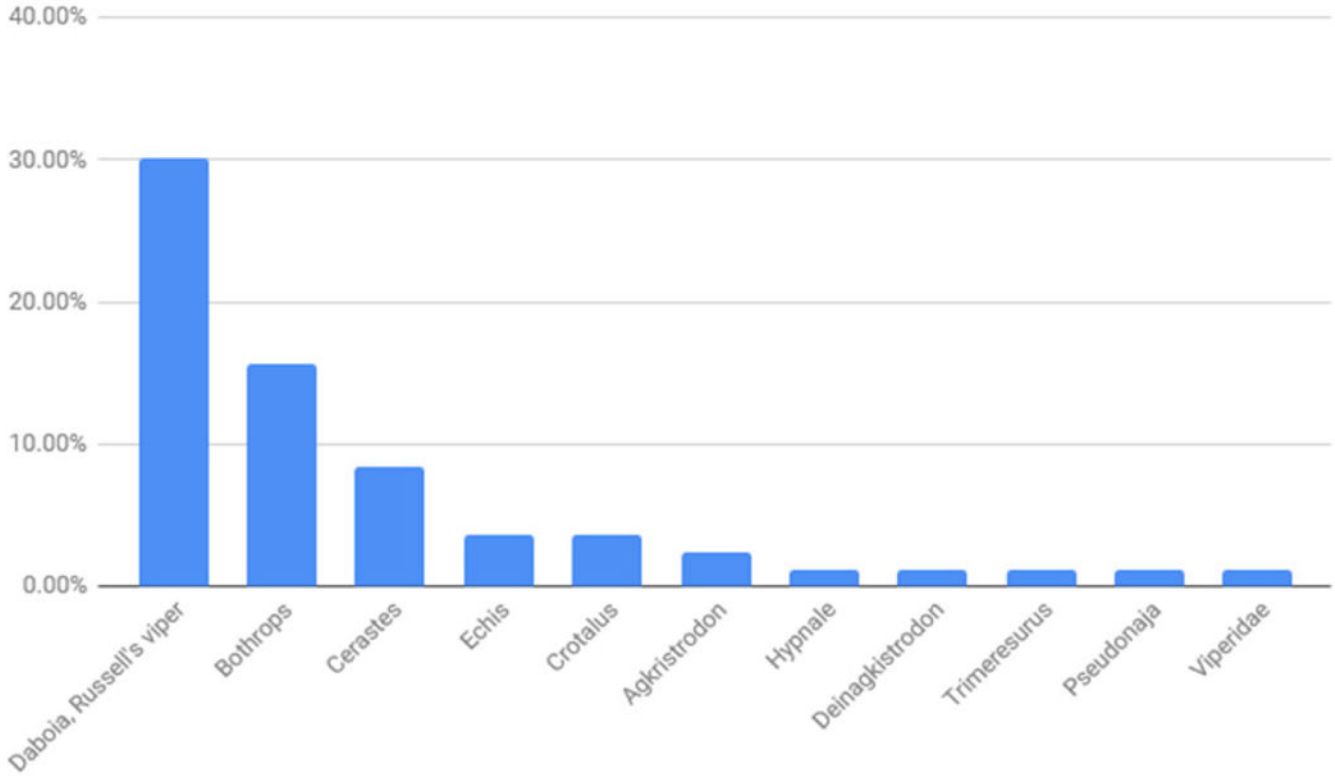

Figure 1:
Frequency of Stroke envenomation by species. Note: 30% of the cases had no information regarding snake species.

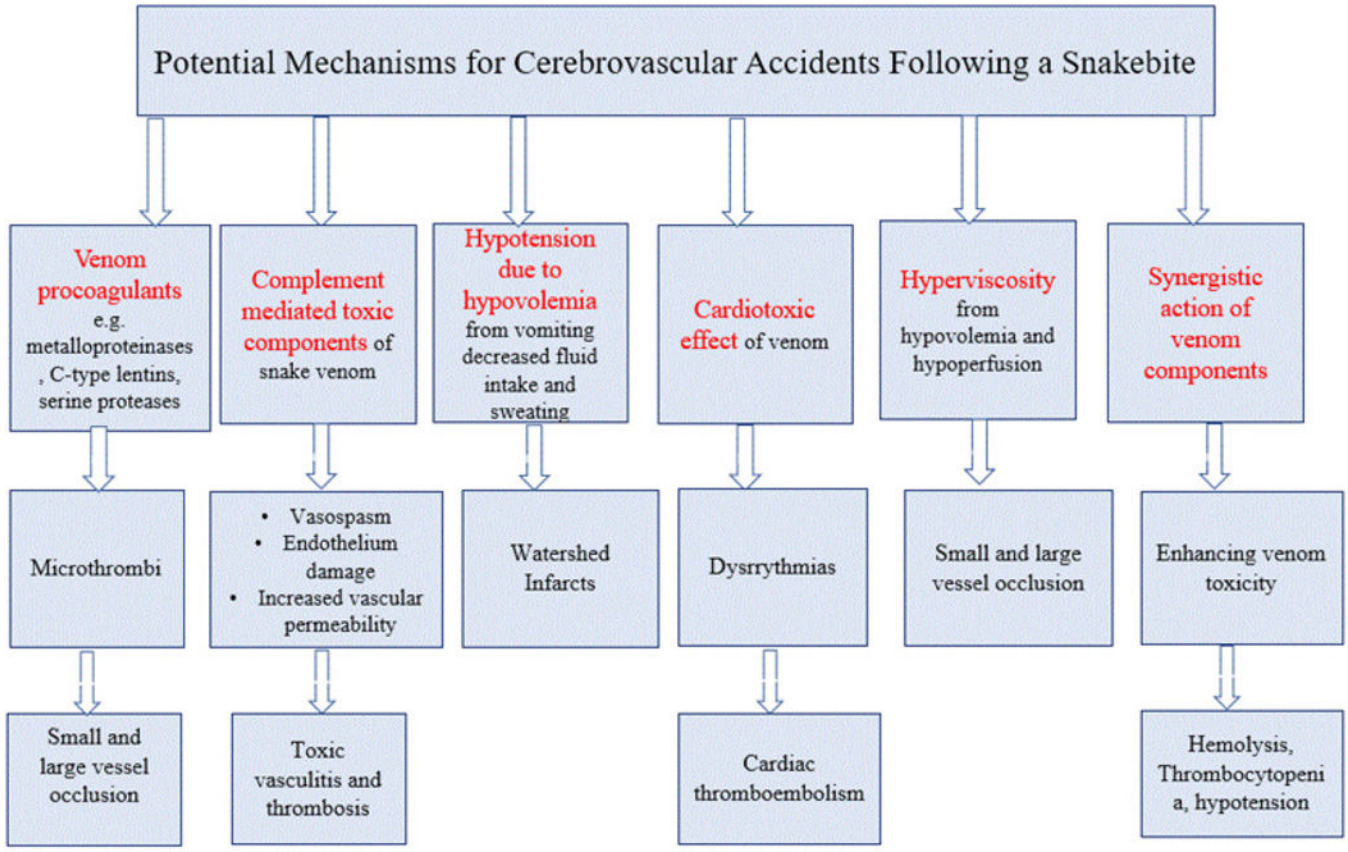

Figure 2:
Postulated mechanisms for cerebrovascular accidents following a snake bite.

Table 1:

Cases reported with snake envenomation associated with stroke [9–78].

Name/Year	Age /Sex	GCS	Symptoms	Onset (hours)	Affected area on CT/MRI	Outcome (Days)
Sahoo AK, 2018	36/M	6	Rt H, aphasia	18	Lt MCA	Full Recovery
Sahoo LK, 2018	36/M	8	Rt H, aphasia, O	1	Lt frontotemporal, Rt basal ganglia, Rt thalamus, occipital, cerebellum	Sequalae
Kutiyal, 2018	26/M	6	Locked-in syndrome	2		Full Recovery
Pothukuchi, 2018	55/M	15	expressive aphasia	1	bilateral frontal lobes	Sequalae
Bakare, 2018	27/M	15	seizures, Rt H	2	Lt parieto-occipital ICH	Full Recovery
Pothukuchi, 2017	70/M	15	Rt H, seizures	96	Lt capsuloganglionic	Full Recovery
	55/M	15	Lf H, aphasia	168	bilateral frontal lobes	Full Recovery
Rathnayaka, 2017	43/M	9	Rt H, seizures	0.75	Lt ICH, sub falcine herniation	Death [11]
Delgado, 2017	58/M	8	Lf H, seizures	4	Rtnucleocapsular ICH	Sequalae
Oliveira, 2017	59/F	3	coma	3.5	SAH, ICH	Death [3]
Janardanaaithala, 2017	38/F	6	coma, abulia	2.5	Lt capsuloganglionic, cerebellum	Sequalae
Swati, 2017	80/M	15	Lt H	2	ICH Rt parietal, occipital/ Lt PICA	Sequalae
Paul, 2017	75/M	10	Rt H, P	24	bilateral cerebellar, Rttemporooccipital	Sequalae
Krishna, 2017	30/F	15	seizures, Rt H	4	Lt capsuloganglionic	Full Recovery
Pal, 2017	21/M	0	Lt H, facial palsy	48	Rt MCA	Sequalae
Abdul Jalal, 2017	48/M	13	Lt H, P	1	ICH Lt frontal, temporal	Full Recovery
Cañas, 2016	48/F	8	Coma, hypotonia, P	96	Basilar artery	Death [3]
Silveira, 2016	52/M	13	dizziness	24	ICH	Full Recovery
Ajit, 2016	30/F	15	Lt H, facial palsy, aphasia	48	Lt fronto-tempo-parietal	Sequalae
Prabhu, 2016	45/F	3	coma, Lt H, P	3	bilateral cerebellum, thalami, frontal and parietal, Rt temporal, midbrain	Sequalae
Jeyaraj, 2016	28/F	15	P, O, facial palsy, Lt H.		Bilateral cerebellar, midbrain, left thalamic with ICH	Full Recovery
Ghezala, 2015	37/M	6	O, decerebration rigidity	4	Subdural hematoma, ICH	Death
Pardal, 2015	10/M	15	Rt H	25	ICH Rt frontal	Sequalae
Gunchan, 2014	36/M	7	Rt, coma	24	basilar artery	Sequalae

	40/M	15	Broca's aphasia	9	superior division of Lt MCA with ICH	Sequalae
Rebahi, 2014	32/F	8	coma	3	frontal, temporal, parietal	Death [5]
	5/F	8	coma	96	Rt frontal temporo-parieto-occipital	Death [7]
	51/M	10	coma, Rt H	48	bilateral internal capsules	Full Recovery
Bush, 2014	50/M	8	Aphasia, Rt H, facial palsy	11	Rt frontal, Lt parietal, lt occipital	Death [3]
	17/M	15	Facial palsy, Lt H	73	Rtsylvian, Rt cerebellum, bilateral frontal, occipital	Sequalae
Mahale, 2014	58/M	15	bilateral homonymous hemianopia	48	Bilateral occipital	Sequalae
Gopalan, 2014	32/F	8	Rt H	6	Lt MCA, Lt ACA, Lt ICA	Sequalae
Chandrashekar, 2014	40/F	15	Rt H, aphasia	6	Lt tempero-parietal	Sequalae
Kumar, 2014	22/M	8	coma	144	ICH Lt parietal	Sequalae
Vale, 2013	16/M	8	top-of-the-basilar syndrome	24	bilateral occipital, Lt temporal, cerebellum	Sequalae
Bhatt, 2013	65/F	10	Aphasia, Rt H	5	Lt precentral, postcentral, hemipons, cerebellum	Sequalae
Das, 2013	27/F	15	Gerstmann's syndrome, P	6	Lt parietofrontal, Lt lateral sinus thrombus	Sequalae
Aissaoui, 2013	72/M	15	Aphasia, Lt hemianopsia	48	Lt occipito-temporoparietal	Full Recovery
Saha, 2013	32/M	9	aphasia, Rt H	6	Lt MCA	Sequalae
Ittyachen, 2012	55/M	12	Coma	5	bilateral thalamic	Sequalae
Chani, 2012	55/M	10	AMS	12	bifocal	Sequalae
Jeevagan, 2012	65/M	15	Lt H	12	Rt parietal	Sequalae
Gupta, 2012	48/F	11	AMS	48	Lt cerebellar	Full Recovery
Gouda, 2011	40/F	9	AMS, hypotonia	1	bilateral cerebellar, occipital	Sequalae
Anim, 2011	48/F	10	AMS	20	Rt cerebellar, medulla, pons	Death [7]
Sathishkuma, 2011	45/M	5	Lt H, AMS	4	Rt MCA	Sequalae
Vale, 2010	24/M	15	Lt H, right homonymous hemianopsia	6	Rt MCA	Sequalae
Machado, 2010	62/F	15	Rt H	2	Lt MCA with ICH	Sequalae
Anim, 2010	32/M	9	AMS, O	24		Sequalae
Narang, 2009	18/M	15	Aphasia, Rt H	24	Lt MCA	Sequalae
Hoskote, 2009	24/M	8	coma, akinetic mute	5	bilateral ACA	Sequalae
Gawarammana, 2009	56/M	13	P, O	7	Cerebellum, bilateral frontal, parietal	Full Recovery
	37/M	14	P,O, Lt H	<1	Rt parietal, lentiform nucleus	Full Recovery
	45/F	14	P,O, Lt H	96	Rt frontal, Rt cerebellum	Full Recovery

	45/F	10	P,O	<1	Lt caudate, bilateral occipital	Sequalae
	8/M	6	P,O	<1	bilateral MCA	Death [5]
	53/M	14	P,O	2	Multiple cortical and cerebellum	Sequalae
	35/M	9	P,O	<1	Lt frontal	Sequalae
	39/M	13	P,O	<1	Multiple cerebellum and occipital	Sequalae
	54/M	15	P,O Lt H	2	Rt parietal-temporal	Sequalae
Mugundhan, 2008	14/M	8	P, O	<1	bilateral cerebellar, Rt occipital	Death [1]
Prakash, 2008	40/M	3	P,O, Locked in syndrome	3		Full Recovery
	25/M	3	P,O, Locked in syndrome	6		Full Recovery
Santos-Soares, 2007	65/F	8	Aphasia, Rt H, Lt facial palsy	12	ICH Lt temporo-parietal	Full Recovery
Das, 2007	22/F	15	Aphasia, Rt H	36	multiple Lt cerebral	Sequalae
Thomas, 2007	46/M	15	Lt inferior quadranopsia	22	bilateral occipital	Full Recovery
	55/M	15	Rt H, aphasia	36	Lt MCA	Sequalae
	66/M	13	Lt H, left homonymous hemianopsia	24	Multiple cortical	Sequalae
Merle, 2005	46/M	15	Lt lateral homonymous quadranopsia	24	Occipital	Full Recovery
Anim, 2004	20/F	15	decreased visual acuity	24		Sequalae
Lee, 2004	72/M	7	Rt H	72	ACA, MCA, subacute PICA	Sequalae
Bartholdi, 2004	22/M	15	Monoparesis of the Lt leg	24	ICH Rt parasagittal	Sequalae
Boviatsis, 2003	65/F	13	Lt H, Rthemianopsia	4	Multiple cerebral	Full Recovery
Zhang, 2003	22/M	3	Rtanisocoria	11	ICH with herniation	Death [2]
Hung, 2003	52/M	15	Monoparesis of the Lt arm	24	bilateral fronto-parieto-occipital, Rt thalamus	Death [3]
Diaz, 2003	11/M	13	Rt facial palsy, lt H	2	Rt MCA	Sequalae
Numeric, 2002	32/M	15	Lt H, Rt Facial palsy, Wernicke’s aphasia	144	Rt ACA	Sequalae
Pinho, 2001	64/F	8	coma, anisocoria	15	ICH	Full Recovery
Lee, 2001	54/F	15	one and-a-half syndrome	4	Proximal basilar artery	Sequalae
Panicker, 2000	21/M	15	Motor aphasia, Rt H	2	Lt frontal	Sequalae
Singh, 1998	23/M	12	coma	36	Rt frontal, parietal, occipital	Death [4]
Medytt, 1998	57/M	11	coma	<1	Bilateral ICH	Death [1]
Cole, 1996	43/M	14	Wernicke aphasia, alexia, uadrantanopia, Rt H	24	Lt temporal with ICH	Sequalae

GCS: Glasgow Coma Scale, CT: Computed Topography, MRI: Magnetic Resonance Imaging, M: Male, F: Female, Lt: Left, Rt: Right, H: Hemiplegia, O: Ophthalmoplegia, P: Ptosis, AMS: Altered Mental Status, ICH: Intra-Cranial Hemorrhage, MCA: Middle Cerebral Artery, ACA: Anterior Cerebral Artery, ICA: Internal Carotid Artery, PICA: Posterior Inferior Cerebral Artery

Int J Clin Res Trials. Author manuscript; available in PMC 2019 September 16.