

Snake Venom Toxins in Cancer Therapy: Current Advances and Future Perspectives

Aleem Munir¹, Waleed Hassan², Huzaifa³, Zubair Iqbal⁴, Hussain Ahmed⁵, Zubair Ahmed⁶

^{1,2,3,4,6}Department of Biological Sciences, International Islamic University Islamabad, Pakistan;

⁵Department of Biological Sciences, COMSATS university Islamabad, Pakistan

ABSTRACT

Background: Cancer remains one of the most serious health challenges worldwide, driving an urgent search for innovative treatments. Efforts to develop effective therapies are ongoing worldwide, with venom and its toxic peptides garnering considerable attention for their therapeutic potential against cancer.

Objective: This review aims to evaluate the potential of venom from snakes, highlighting their effects on various cancer cell lines.

Methodology: Published literature was examined to identify experimental and preclinical studies reporting anticancer activities of venoms and venom-derived peptides. Studies involving various cancer cell lines and mechanistic evaluations were included.

Results: Studies show that these venoms can inhibit tumor growth, slow down the division of cancer cells, and reduce the progression of the disease. According to recent findings, venoms of snakes demonstrated anticancer activities involving mechanisms like apoptotic, antimetastatic, immunomodulation, multispecific targeting, cytotoxic, antiangiogenic, and antiproliferative. The cancer cell lines, including lung, breast, liver, colorectal, skin, brain, and blood, were inhibited by the venom of these organisms.

Conclusion: These findings offer hope, pointing to the potential of venom-based therapies to contribute to future breakthroughs in cancer treatment.

Keywords: Cancer therapy, Snake, Toxins, Venom

Authors' Contribution:

All authors contributed equally to the conception, literature search, manuscript drafting, editing and review

Correspondence:

Aleem Munir
Email: aleemunir457@gmail.com

Article info:

Received: March 02, 2026
Accepted: March 15, 2026

Cite this article. Munir A, Hassan W, Huzaifa, Iqbal Z, Ahmed H, Ahmed Z. Snake Venom Toxins in Cancer Therapy: Current Advances and Future Perspectives. J Islamabad Med Dental Coll. 2026; 15(1): 91-98.

DOI: <https://doi.org/10.35787/jimdc.v15i1.1564>

Funding Source: Nil

Conflict of interest: Nil

Introduction

Cancer poses a significant global challenge due to its high incidence, diverse etiologies, and complex treatment requirements. In 2019, there were approximately 23.6 million new cancer cases globally, and 10 million deaths, making it the second leading cause of death worldwide, following cardiovascular diseases.¹⁻³ The global burden of cancer continues to rise, with a staggering 1,898,160

new cases and 608,570 deaths estimated in the United States alone in 202 whereas, in Europe, according to a survey in 2020, about 23711 thousand people were alive after a cancer diagnosis and 22347 thousand in the EU27. The cancer survivors were more frequently female than male.⁴ This immense struggle to counter the global cancer burden drives an urgent search for innovative treatments. Cancer is gaining great attention from world research due to its different etiology and types,

including carcinomas affecting skin or tissues that line internal organs (Lung, Breast, Prostate, and colon cancer). Sarcomas affecting bone, fat or muscle (osteosarcoma, liposarcoma), lymphomas affecting lymphatic system (Hodgkin lymphoma), melanomas simulating melanocytes (skin melanoma), brain and spinal cord cancers (glioblastoma, astrocytoma), germ cell tumors (testicular & ovarian cancer), neuroendocrine tumors and some other specific tumors like thyroid, bladder and kidney cancers.^{5,6} According to a survey in Europe, the leading tumors were breast cancer, corpus uterine cancer, skin melanoma, colorectal cancer, and thyroid cancer in females whereas Prostate cancer, urinary bladder cancer, colorectal cancer, skin melanoma, and kidney cancer were frequently diagnosed in males.⁷ On the other hand, in Asia, the most common cancers reported were colorectal (10.6%), breast (10.8%), and lung (13.8%), with the highest death ratio caused by lung cancer.⁸ Therefore, a substantial effort is required to address this global burden.

Although venoms are highly toxic and frightening, they also have significant benefits. Toxicology research on venom has made significant strides, opening new avenues in cancer treatment development. Venom has shown promising effectiveness in fighting cancer, with researchers exploring its potential to target and destroy cancer cells without harming healthy tissue.⁹ When discussing venom, the toxins of snakes are the first to come to mind, and, more recently, these are being studied to advance cancer therapies. This review critically evaluates the therapeutic potential of these organisms.

Snake Venom: Snake venom is a complex, species-specific mixture of bioactive molecules, including proteins, toxic peptides, and enzymes, primarily designed to immobilize, kill, and digest prey. This rich composition makes it a promising source for new, naturally extracted anticancer compounds. While its exact components vary greatly, venom generally includes enzymes, toxins (such as

Neurotoxins, Hemotoxins, and Cytotoxins), metalloproteinases, phospholipases, and polypeptides.⁹⁻¹¹ These peptides and toxins have been studied for effective and possible treatment of cancer, as in a study, the venom of the Malaysian cobra exhibits potential anti-cancer properties, offering a valuable avenue for researchers to investigate in the development of cancer treatments.¹² However, conflicting evidence suggests cytotoxic effects of king cobra venom differ between hatchlings and adults, with Malaysian cobra venom displaying slightly higher toxicity due to their distinct ecological roles. However, all venoms demonstrate comparable anticancer potential against melanoma cells and fibroblasts.¹³ Cobra and cytotoxins demonstrate potent anticancer effects like two cobra snakes *Naja kaouthia* and *Naja sumatrana*, but their selectivity for specific cancers remains limited.¹⁴ The cobra venom also includes L-amino acid oxidases (LAAO), like *Ophiophagus hannah* snake, which has LAAO in its venom, which showed extremely potent antiproliferative activity against the proliferative cancer cells. It shows promise as a potential treatment for solid tumors due to its heat stability and targeted antitumor effects.¹⁵

Snake Venom Activity Against Breast Cancer: Breast cancer is a major global health concern, impacting millions of women around the globe. As one of the most prevalent cancers, it has high occurrence rates in both developed and developing nations.¹⁶ In an experimental approach, the cytotoxin-II derived from cobra venom was investigated against the human breast adenocarcinoma cell line (MCF-7), exhibiting strong anticancer activity against the MCF-7 cell line, triggering apoptosis through intrinsic pathways. The findings were extremely promising; maximal inhibitory concentration of IC50 of cytotoxin-II in MCF-7 cells was measured at $4.18 \pm 1.23 \mu\text{g/mL}$, compared to around $28.02 \pm 1.87 \mu\text{g/mL}$ for cisplatin. Morphological assessment and AO/EtBr double staining revealed characteristic signs of apoptotic cell death.¹⁷ Combining snake

venom with nanoparticles greatly boosts its antitumor effects, leading to reduced tumor sizes, elevated levels of reactive oxygen species (ROS), and the induction of apoptosis in breast cancer cells.¹⁸ According to recent findings, snake venom triggers apoptosis in breast cancer cells via multiple mechanisms, such as activating caspases and regulating Bcl-2 family proteins. This apoptotic effect has been demonstrated in several studies using various types of snake venom.¹⁸ Snake venom also demonstrates cytotoxic effects on breast cancer cells, decreasing cell viability in a manner that depends on both the dose and exposure time. The toxicity was notably greater in cancer cells than in normal cells.¹⁹ In a study, contortrostatin (CN), a disintegrant derived from the venom of the Southern Copperhead snake, exhibited strong antiangiogenic properties and hinders the progression of breast cancer when delivered through liposomes. It achieved this by targeting integrins on both tumor and endothelial cells.²⁰

Lung Cancer: Research on the application of snake venom in cancer treatment, especially for lung cancer, has yielded encouraging outcomes. Snake venom has the potential to amplify the cytotoxic activity of natural killer (NK) cells against lung cancer cells, resulting in marked suppression of tumor growth and heightened apoptosis (Fig. 1). This occurs through the suppression of NF- κ B and the increased expression of apoptotic proteins such as Bax and caspase-3.²¹ Snake venom also has an anti-metastatic effect. Disintegrins derived from snake venom impede tumor cell adhesion, migration, angiogenesis, and metastasis by interacting with integrins on the outer surfaces of cells. This action makes them effective in slowing tumor growth and progression.²² Snake venom and its components demonstrate direct cytotoxicity against lung cancer cells, triggering apoptosis through pathways that involve the stimulation of caspase-3 and caspase-9. Like certain venom fractions, including those from *Pseudocerastes persicus* and *Vipera lebetina*, displayed significant cytotoxic and anti-adhesive

properties in lung cancer cells (23). Snake venom components exert antitumor effects through several mechanisms, including direct cytotoxicity, the production of free radicals, the initiation of apoptosis, and the inhibition of angiogenesis. Important enzymes contributing to these actions include C-type lectins, metalloproteases, LAAOs, and PLA2.²⁴ The anticancer activity of snake venoms has been studied since the 1930s. Contemporary studies continue to examine the structural and functional characteristics of venom components in the pursuit of new anticancer therapies. Moreover, snake venom-derived peptides and proteins possess unique qualities, including high specificity and cytotoxicity against tumor cells, making them prime candidates for the development of novel drugs for cancer treatments. However, further research is necessary to affirm their safety and effectiveness.²⁵

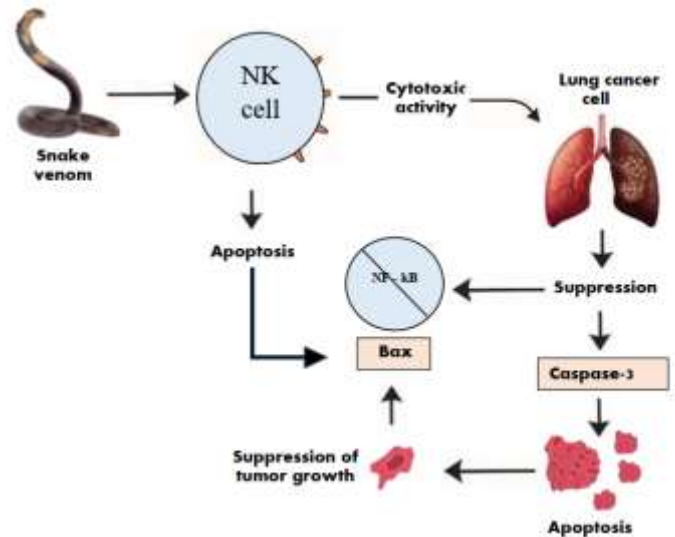


Figure 1: Amplification of cytotoxic activity of NK cells by snake venom against lung cancer cells.

Hepatocellular Carcinoma (HCC): There have been promising findings from studies on the use of snake venom as a possible treatment for liver cancer, especially hepatocellular carcinoma. The anti-proliferative effects on HepG2 cells were increased when snake venom or its component LAAO was conjugated with sorafenib (SOR). In contrast, THLE-2 normal cells showed increased safety. This

combination showed a strong synergistic anti-tumor effect by significantly increasing apoptotic gene expression and decreasing anti-apoptotic genes.²⁶ Tumor cells were significantly more vulnerable to the cytotoxic effects of snake venom and its isolated enzymes, such as LAAO, than healthy cells. These substances are promising options for cancer treatment because they induce apoptosis through mechanisms like oxidative stress and mitochondrial dysfunction.²⁷ Furthermore, the venom of the Persian Gulf Sea snake (*Enhydrina schistosa*) enhanced ROS generation, altered mitochondrial membrane potential, and promoted cytochrome C release in hepatocytes and mitochondria from HCC models. These outcomes show its potential as a supplementary treatment agent for treating HCC.²⁸ The mechanisms of action include direct cytotoxicity, free radical production, apoptosis induction, and suppression of angiogenesis.²⁹ Ongoing research into the structural and functional properties of snake venom components is crucial for developing and advancing innovative anti-liver cancer drugs. Improvements in modern technologies have enhanced the extraction and identification of new therapeutic agents from snake venoms.³⁰

Colorectal Cancer: Research on the potential of snake venom against colorectal cancer produced significant results. Here are some key findings from multiple studies. According to these studies, components of snake venom, especially LAAOs, showed strong cytotoxic and pro-apoptotic effects on colorectal cancer cells by creating oxidative stress and disrupting the cellular redox balance.³¹ Furthermore, toxins like Bjussu-LAAO-II from *Bothrops jararacussu* venom cause oxidative stress, damage DNA, and alter the expression of genes related to inflammation and apoptosis, ultimately leading to cell death in colorectal cancer cells.³² Snake venom significantly reduces cell motility, colony formation, and invasiveness in colorectal cancer cell lines, demonstrating its potential to delay cancer growth.³¹

According to recent studies, the venoms of *Echis coloratus* and *Walterinnesia aegyptia* produced apoptosis and resulted in cell cycle arrest in colorectal cancer cell lines. This changed the expression of some regulatory proteins like p53, p21, and cyclin D1. Similarly, Lebein (Disintegrins), present in the venom of *Macrovipera lebetina*, also induced apoptosis through pathways involving the p53 status of cancer cells.³³ Moreover, recent studies have also shown that snake venom induces autophagic cell death of colorectal cancer cells through pathways involving activation of JNK pathways, pointing to a new mode of action.³⁴ According to another recent approach conducted, *Echis coloratus* showed tumor-suppressive inflammatory responses through an increase of anti-cancer and a decrease of pro-tumorigenic cytokines, chemokines, and other factors for colorectal cancer cells.³⁵

Skin, Brain, Blood Cancer: Snake venom and toxins also demonstrated promising results regarding skin, brain, and blood cancer. Snake venom has strong potential against skin cancer, representing cytotoxic, anti-metastatic, and anti-proliferative properties. Special venom components like LAAOs, disintegrins, and metalloproteases (MPs) express antitumor activities.³⁰ Lebein (Disintegrins) have shown the ability to inhibit melanoma cell growth, promote apoptosis, and decrease cell invasiveness by disrupting integrin-related signaling pathways. Lebein, in particular, prevents the proliferation of melanoma cells, promotes a more differentiated cell state, and activates an apoptotic process that occurs independently of caspases.³⁶ Like the treatment of skin cancer from venom components, brain tumors can also be treated with venom. Bioactive molecules found in snake venom, including disintegrins, phospholipases A2 (PLA2s), and LAAOs, are being studied for their potential as new anti-cancer therapies, with several already demonstrating encouraging outcomes in preclinical studies.¹² Components of snake venom, such as PLA2s, LAAOs, and MPs, show cytotoxic activity against tumor cells,

trigger apoptosis, and produce free radicals, ultimately causing cell death.³⁷ On the other hand, against blood cancer, snake venoms have been studied for their safe medicinal use. Snake venom is comprised of different molecules like toxic peptides, proteins, and enzymes that have been proven to be effective against cancer cells, especially blood malignancies. The main molecules of snake venom, including LAAOs and PLA2s, can reduce blood cancer due to their apoptotic and cytotoxic effects. Moreover, many other phenomena like cell adhesion, migration, angiogenesis, and metastasis have been shown by disintegrins and C-type lectins to have affinity with surface integrins on cancer cells, resulting in tumor suppression. These molecules are promising options for treating blood cancers.²⁷ Many recent and historical studies have shown the potential of these venoms in fighting against cancer therapy. Advances in modern technology have made possible the extraction and identification of new anticancer therapeutic molecules from snake venom, paving the way for the discovery and development of effective cancer medicines.

Methodology

We conducted a comprehensive literature search using PubMed, Scopus, Google Scholar, and Web of Science to identify relevant studies published up to February 2025. The search strategy incorporated keywords and combinations of terms such as “cancer therapies,” “snake venom,” “in vitro studies,” “in vivo studies,” “pharmacological effects,” “clinical application,” “acupuncture,” “acupoints,” and “apitherapy.”

For inclusion in this review, we considered peer-reviewed research articles with a Digital Object Identifier (DOI) and an International Standard Serial Number (ISSN), as well as book chapters carrying an International Standard Book Number (ISBN). We excluded non-peer-reviewed materials, studies without accessible full texts, duplicate records retrieved from multiple databases, conference

abstracts, retracted publications, and articles lacking sufficient methodological detail. Additionally, studies not directly related to snake, honeybee, or spider venoms were omitted.

To minimize bias and ensure scientific rigor, priority was given to experimental and preclinical studies that provided mechanistic insights and demonstrated anticancer effects across various cancer cell lines

Discussion

The preceding sections have highlighted the significant potential of venoms from snakes, honeybees, and spiders as a source of novel anticancer agents. The observed mechanisms, including apoptosis induction, anti-metastatic effects, and multispecific targeting, demonstrate a promising avenue for drug discovery. However, translating these preclinical successes into clinical practice is fraught with challenges that must be addressed critically.

Limitations and Current Hurdles: Despite the encouraging results, several significant limitations and hurdles must be acknowledged.

Toxicity, Lack of Selectivity, and Reporting Bias: A primary concern is the inherent toxicity and lack of selectivity of many venom compounds. As noted in the snake venom section, substances like the cytotoxins from *Naja kaouthia* and *Naja sumatrana* exhibit potent anticancer effects, but their selectivity for specific cancer types remains limited [15]. This lack of precise targeting poses a substantial safety risk, as these compounds can harm healthy cells alongside cancerous ones. Furthermore, a more balanced scientific review must acknowledge that the current literature may underreport negative results, as studies in which venom failed to show efficacy or demonstrated excessive toxicity are often not widely published.

Over-reliance on Preclinical Studies: The findings presented are based on preclinical studies (*in vitro* and *in vivo* animal models). There is a critical lack of

extensive human clinical trial data to validate the safety, efficacy, and optimal dosing of these treatments, which is a significant barrier to their translation into approved medical therapies.

Practical Challenges in Development: Translating venom-derived bioactive compounds into clinically viable anticancer therapeutics presents several formidable challenges that continue to limit their progress beyond the experimental stage. Foremost among these is the complexity of venom composition itself: most venoms consist of highly diverse, heterogeneous mixtures of peptides, enzymes, and non-protein components, whose bioactivities are often synergistic rather than additive. Disentangling these interactions and achieving consistent isolation, purification, and chemical characterization of the specific anticancer constituents remains a technically demanding and resource-intensive endeavor. Moreover, establishing standardized production pipelines for naturally sourced or recombinant analogs is essential for regulatory approval but remains far from routine.

Finally, the success of venom-derived anticancer agents depends on the development of targeted delivery strategies that transport these molecules directly to tumor tissues while minimizing collateral damage to healthy cells. Given their inherent cytotoxicity, non-specific distribution presents significant safety risks and diminishes therapeutic potential. Advances in nanocarriers, ligand-mediated delivery, and stimuli-responsive systems offer promising avenues, yet clinical translation remains hindered by challenges in scale-up, biocompatibility, and regulatory validation. Collectively, these limitations underscore the necessity for multidisciplinary innovation to bridge the gap between laboratory discovery and effective, safe, and targeted clinical applications.

Future Directions: Future research must focus on overcoming the current limitations to unlock the full therapeutic potential of venoms.

Future Prospects vs. Current Hurdles: The Role of Nanomedicine: While the current hurdles of toxicity and delivery are significant, advanced biotechnology and nanomedicine offer a clear path forward. The development of targeted and precise delivery systems, such as functionalized nanoparticles and liposomes, is not merely an optimistic prospect but a necessary and achievable solution to the problems of non-selectivity and systemic toxicity. This approach can encapsulate active venom components and release them specifically at the tumor site, thereby bridging the gap between the severity of current problems and the optimism for future solutions.

Addressing Conflicting Evidence: The presence of conflicting evidence, such as the variation in cytotoxic effects of king cobra venom between hatchlings and adults, underscores the need for more rigorous and standardized research protocols. Future studies should focus on elucidating the mechanisms underlying these variations to ensure consistent, reproducible results across studies.

Conclusion

The review confirms that venoms from snakes, honeybees, and spiders contain a rich array of bioactive molecules with demonstrable anticancer properties in preclinical settings. While these findings offer hope for future breakthroughs in cancer treatment, the path forward requires a concerted effort to address the critical challenges of toxicity, lack of selectivity, and the need for human clinical validation. By focusing on species-specific mechanisms, developing nanomedicine-based targeted delivery, mitigating immunological risks, and standardizing research, venom-based therapeutics can move closer to becoming a viable component of the oncology pharmacopeia.

References

1. Xavier CPR, Palmeira A. Special Issue: "Drug Repurposing for Cancer Therapies". International journal of molecular sciences. 2024;25(2).

2. Kocarnik JM, Compton K, Dean FE, Fu W, Gaw BL, Harvey JD, et al. Cancer Incidence, Mortality, Years of Life Lost, Years Lived With Disability, and Disability-Adjusted Life Years for 29 Cancer Groups From 2010 to 2019: A Systematic Analysis for the Global Burden of Disease Study 2019. *JAMA oncology*. 2022;8(3):420-44.
3. Collaborators GDal. Global incidence, prevalence, years lived with disability (YLDs), disability-adjusted life-years (DALYs), and healthy life expectancy (HALE) for 371 diseases and injuries in 204 countries and territories and 811 subnational locations, 1990-2021: a systematic analysis for the Global Burden of Disease Study 2021. *Lancet (London, England)*. 2024;403(10440):2133-61.
4. Siegel RL, Miller KD, Fuchs HE, Jemal A. *Cancer Statistics, 2021*. CA: a cancer journal for clinicians. 2021;71(1):7-33.
5. Rock CL, Thomson CA, Sullivan KR, Howe CL, Kushi LH, Caan BJ, et al. American Cancer Society nutrition and physical activity guideline for cancer survivors. CA: a cancer journal for clinicians. 2022;72(3):230-62.
6. Siegel RL, Wagle NS, Cercek A, Smith RA, Jemal A. *Colorectal cancer statistics, 2023*. CA: a cancer journal for clinicians. 2023;73(3):233-54.
7. De Angelis R, Demuru E, Baili P, Troussard X, Katalinic A, Chirlaque Lopez MD, et al. Complete cancer prevalence in Europe in 2020 by disease duration and country (EUROCARE-6): a population-based study. *The Lancet Oncology*. 2024;25(3):293-307.
8. Huang J, Tin MS, Ngai CH, Lok V, Deng Y, Zhang L, et al. AB034. Cancer incidence and mortality in Asian countries: a trend analysis. 2021. 2021;5.
9. Post Y, Puschhof J, Beumer J, Kerckamp HM, de Bakker MAG, Slagboom J, et al. Snake Venom Gland Organoids. *Cell*. 2020;180(2):233-47.e21.
10. Tasoulis T, Isbister GK. A current perspective on snake venom composition and constituent protein families. *Archives of toxicology*. 2023;97(1):133-53.
11. da Silva JR, Castro-Amorim J, Mukherjee AK, Ramos MJ, Fernandes PA. The application of snake venom in anticancer drug discovery: an overview of the latest developments. *Expert Opin Drug Discov*. 2025:1-19.
12. Zainal Abidin SA, Lee YQ, Othman I, Naidu R. Malaysian Cobra Venom: A Potential Source of Anti-Cancer Therapeutic Agents. *Toxins*. 2019;11(2).
13. Op den Brouw B, Fernandez-Rojo MA, Charlton T, Fry BG, Ikonopoulou MP. Malaysian and Chinese King Cobra Venom Cytotoxicity in Melanoma and Neonatal Foreskin Fibroblasts Is Mediated by Age and Geography. *Toxins*. 2023;15(9).
14. Chong HP, Tan KY, Tan CH. Cytotoxicity of Snake Venoms and Cytotoxins From Two Southeast Asian Cobras (*Naja sumatrana*, *Naja kaouthia*): Exploration of Anticancer Potential, Selectivity, and Cell Death Mechanism. *Frontiers in molecular biosciences*. 2020;7:583587.
15. Li Lee M, Chung I, Yee Fung S, Kanthimathi MS, Hong Tan N. Antiproliferative activity of king cobra (*Ophiophagus hannah*) venom L-amino acid oxidase. *Basic & clinical pharmacology & toxicology*. 2014;114(4):336-43.
16. Barzaman K, Karami J, Zarei Z, Hosseinzadeh A, Kazemi MH, Moradi-Kalbolandi S, et al. Breast cancer: Biology, biomarkers, and treatments. *International immunopharmacology*. 2020;84:106535.
17. Ebrahim K, Shirazi FH, Vatanpour H, Zare A, Kobarfard F, Rabiei H. Anticancer Activity of Cobra Venom Polypeptide, Cytotoxin-II, against Human Breast Adenocarcinoma Cell Line (MCF-7) via the Induction of Apoptosis. *Journal of breast cancer*. 2014;17(4):314-22.
18. Al-Sadoon MK, Abdel-Maksoud MA, Rabah DM, Badr G. Induction of apoptosis and growth arrest in human breast carcinoma cells by a snake (*Walterinnesia aegyptia*) venom combined with silica nanoparticles: crosstalk between Bcl2 and caspase 3. *Cellular physiology and biochemistry : international journal of experimental cellular physiology, biochemistry, and pharmacology*. 2012;30(3):653-65.
19. Kisaki CY, Arcos SSS, Montoni F, da Silva Santos W, Calacina HM, Lima IF, et al. Bothrops Jararaca Snake Venom Modulates Key Cancer-Related Proteins in Breast Tumor Cell Lines. *Toxins*. 2021;13(8).
20. Swenson S, Costa F, Minea R, Sherwin RP, Ernst W, Fujii G, et al. Intravenous liposomal delivery of the snake venom disintegrin contortrostatin limits breast cancer progression. *Molecular cancer therapeutics*. 2004;3(4):499-511.
21. Oh JW, Song HS. Snake Venom synergized Cytotoxic Effect of Natural Killer Cells on NCI H358 Human Lung Cancer Cell Growth through Induction of Apoptosis. *Journal of Acupuncture Research*. 2016;33(2):1-9.
22. Calderon LA, Sobrinho JC, Zaqueo KD, de Moura AA, Grabner AN, Mazzi MV, et al. Antitumoral activity of snake venom proteins: new trends in cancer therapy. *BioMed research international*. 2014;2014:203639.
23. Oghalaie A, Kazemi-Lomedasht F, Zareinejad MR, Shahbazzadeh D. Antiadhesive and cytotoxic effect of Iranian *Vipera lebetina* snake venom on lung epithelial cancer cells. *Journal of family medicine and primary care*. 2017;6(4):780-3.
24. Urra FA, Araya-Maturana R. Putting the brakes on tumorigenesis with snake venom toxins: New molecular insights for cancer drug discovery. *Seminars in cancer biology*. 2022;80:195-204.

25. Shanbhag VKL. Applications of snake venoms in treatment of cancer. *Asian Pacific Journal of Tropical Biomedicine*. 2015;5(4):275-6.
26. Mahfouz DH, El-Magd MA, Mansour GH, Wahab AHA, Abdelhamid IA, Elzayat E. Therapeutic potential of snake venom, l-amino oxidase and sorafenib in hepatocellular carcinoma. *Molecular Cellular Toxicology* 2021;1-12.
27. Nikodijević DD, Jovankić JV, Cvetković DM, Anđelković MZ, Nikezić AG, Milutinović MG. L-amino acid oxidase from snake venom: Biotransformation and induction of apoptosis in human colon cancer cells. *European journal of pharmacology*. 2021;910:174466.
28. Seydi E, Tajarri P, Naserzadeh P, Pourahmad JJIJoPS. A Search for Anti-Carcinogenic and Cytotoxic Effects of Persian Gulf Sea Snake (*Enhydrina schistosa*) Venom on Hepatocellular Carcinoma Using Mitochondria Isolated from Liver: Cytotoxic effects of *Enhydrina schistosa* venom. 2020;16(1):29-38.
29. Akhtar B, Muhammad F, Sharif A, Anwar MI. Mechanistic insights of snake venom disintegrins in cancer treatment. *European journal of pharmacology*. 2021;899:174022.
30. Li L, Huang J, Lin Y. Snake Venoms in Cancer Therapy: Past, Present and Future. *Toxins*. 2018;10(9).
31. Al-Asmari AK, Riyasdeen A, Al-Shahrani MH, Islam M. Snake venom causes apoptosis by increasing the reactive oxygen species in colorectal and breast cancer cell lines. *OncoTargets and therapy*. 2016;9:6485-98.
32. Machado ART, Aissa AF, Ribeiro DL, Hernandez LC, Machado CS, Bianchi MLP, et al. The toxin BjussuLAAO-II induces oxidative stress and DNA damage, upregulates the inflammatory cytokine genes TNF and IL6, and downregulates the apoptotic-related genes BAX, BCL2 and RELA in human Caco-2 cells. *International journal of biological macromolecules*. 2018;109:212-9.
33. Zakraoui O, Marcinkiewicz C, Aloui Z, Othman H, Grépin R, Haoues M, et al. Lebein, a snake venom disintegrin, suppresses human colon cancer cells proliferation and tumor-induced angiogenesis through cell cycle arrest, apoptosis induction and inhibition of VEGF expression. *Molecular carcinogenesis*. 2017;56(1):18-35.
34. Yu JE, Yeo IJ, Lee DW, Chang JY, Son DJ, Yun J, et al. Snake venom induces an autophagic cell death via activation of the JNK pathway in colorectal cancer cells. *Journal of Cancer*. 2022;13(12):3333-41.
35. Daghestani MH, H. Hakami H, Ambreen K, Saleem AM, Aleisa NA, Al Neghery LM, et al. Assessment of tumor-suppressive inflammatory tendency of *Echis coloratus* venom against colon carcinogenesis, via up-regulation of anti-tumorigenic inflammatory cells and down-regulation of pro-tumorigenic inflammatory cells, in colon cancer cell lines. *Toxin Reviews* 2022;41(1):11-24.
36. Hammouda MB, Montenegro MF, Sánchez-Del-Campo L, Zakraoui O, Aloui Z, Riahi-Chebbi I, et al. Lebein, a Snake Venom Disintegrin, Induces Apoptosis in Human Melanoma Cells. *Toxins*. 2016;8(7).
37. Offor BC, Piater LA. Snake venom toxins: Potential anticancer therapeutics. *Journal of applied toxicology : JAT*. 2024;44(5):666-85.