NEWS FROM THE PIT

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The Controversial History of Pressure Bandage Immobilization and Rattlesnake Envenomation

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In 2010 the American Heart Association and the American Red Cross published a first aid recommendation regarding pressure bandage immobilization, also called pressure-immobilization, favoring its use for bites by “non-neurotoxic” snakes (including rattlesnakes) in the United States.[1,2] This was a new perspective, reversing their previous 2005 guidance, which stated that there was insufficient evidence to make a recommendation regarding use of pressure bandage immobilization for bites by “non-elapid” snakes in the United States.

It is important to note that in the context of these publications, the terms “non-neurotoxic” and “non-elapid” are used to differentiate rattlesnakes, water moccasins, and copperheads that belong to the taxonomic family Viperidae and produce significant tissue injury, from coral snakes that belong to the family Elapidae and produce predominantly neurotoxic effects.

NEWSLETTER HIGHLIGHTS

Controversial historical use of pressure bandage immobilization for snakebites

Image 1: Western Diamondback (*Crotalus atrox*)

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2010 *Circulation* recommendation of pressure bandage immobilization for snakebites in the United States:

> "Initially it was theorized that slowing lymphatic flow by external pressure would only benefit victims bitten by snakes producing neurotoxic venom, but the effectiveness of pressure immobilization has also been demonstrated for bites by non-neurotoxic American snakes."
> [Note: The original 2010 language is quoted above. The current online iteration of this publication (accessed 06 May 2025) can be found at https://doi.org/10.1161/CIRCULATIONAHA.110.971150. The currently available online version contains the 2014 changes deleting a coral snake reference found in the original and adding the qualification "...in an animal model" to the sentence underlined above.]

2005 *Circulation* recommendation of pressure bandage immobilization for snakebites in the United States:

> "In case of an elapid (eg, coral) snakebite, wrap a bandage snugly (comfortably tight but loose enough to slip or fit a finger under it) around the entire length of the bitten extremity, immobilize the extremity, and get definitive medical help as rapidly as possible. Wrapping the extremity slows dissemination of venom by slowing lymph flow. There is a paucity of studies evaluating whether pressure and immobilization bandage are effective in bites by nonelapid snakes."
>
> [https://doi.org/10.1161/CIRCULATIONAHA.105.166575 (accessed 06 May 2025)]

In this month's newsletter we are going to talk about the history of pressure bandage immobilization and the impact of the 2010 recommendation change. Ultimately, the controversy it created would result in the American Heart Association and the American Red Cross reversing their position BACK to discouraging use of pressure bandage immobilization for rattlesnake bites in 2024.

2024 *Circulation* recommendation of pressure bandage immobilization for snakebites in the United States:

> "More than 95% of venomous bites in North America are caused by crotaline snakes (Crotalinae, also known as pit vipers), specifically rattlesnakes, copperheads, and cottonmouths. Venom from crotaline snakes causes tissue injury and may also cause low blood pressure, bleeding, and muscle fasciculations leading to paralysis. Wounds are generally red, warm, tender, and swollen."
> Table of recommendations: "The use of pressure immobilization bandaging to treat snake bites is potentially harmful."
>
> [https://doi.org/10.1161/CIR.0000000000001281 (accessed 06 May 2025)]

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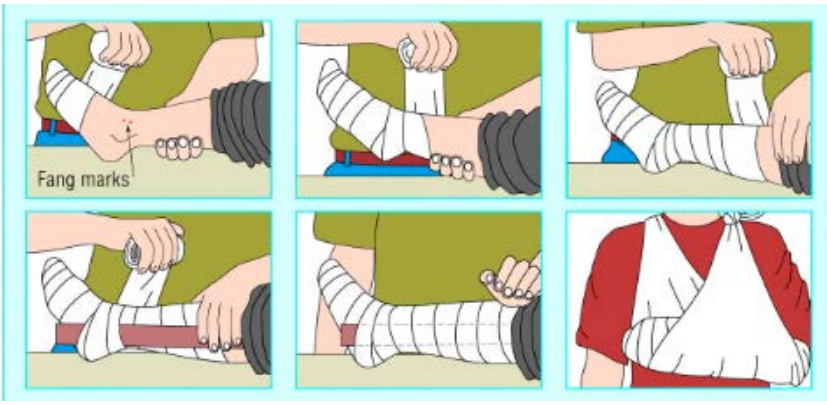
Let's start our journey today by looking at what some of the other currently published guidance documents recommend regarding the use of pressure bandage immobilization. The Arizona Poison and Drug Information Center normally recommends following the unified treatment algorithm as a general guideline for managing rattlesnake envenomations. However, this document doesn't address any prehospital measures.[3] Instead, we are going to look at the Wilderness Medical Society's 2015 guideline for pitviper envenomations in the United States and Canada where they did address prehospital measures, including pressure bandage immobilization as follows:

2015 Wilderness Medical Society Practice Guidelines for the Treatment of Pitviper Envenomations in the United States and Canada:

> "Clinical evidence for pressure bandaging with elastic or cohesive bandaging is limited, and it does not appear to have any benefit in crotaline envenomations. Pressure bandaging is thought to restrict the blood flow and progression of venom to systemic circulation by reducing lymphatic and venous return. One study using a porcine model with a lethal dose of venom showed pressure immobilization increased intracompartmental pressure after envenomation and delayed mortality. Only when treating life-threatening snakebites containing neurotoxic venom (such as Australian elapids) does evidence support containing the venom with pressure bandaging. These results have not been replicated in the United States and Canada where crotaline venom causes more localized tissue damage, and pressure bandaging may instead increase the severity of tissue damage; one animal study demonstrated lethal hyperkalemia when the pressure wrap was removed. Furthermore, two studies indicated that physicians and laypeople rarely apply pressure bandaging correctly, and a third showed that even after training, practitioners were still unsuccessful at effective immobilization in cases of simulated snakebites. Pressure bandaging has not been proven beneficial in studies and case series involving crotaline envenomations. (Not recommended)."[4]



Application of pressure-immobilization technique (from Warrell, D. BMJ 2005;331. doi.org/10.1136/bmj331.7527.1244)

Eastern brown snake (*Pseudonaja textilis*), one of the neurotoxic Australian snakes for which pressure-immobilization first aid was developed. Photo by Tom Frisby.

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Pressure bandage immobilization for venomous snakebites first came about in Australia in the late 1970s for the purpose of temporarily sequestering life-threatening neurotoxins at the site of envenomation. The idea behind it was based on the presumption that envenomations causing paralysis prior to reaching medical care would likely be fatal, and that delaying absorption of venom with effective pressure bandage immobilization could potentially save lives. Conceptually it makes sense in this context and presents a simple option to limit fatalities for people residing in regions where venomous snakes can cause paralysis. This is the point where we start to run into a problem with the idea of pressure bandage immobilization in the United States, because fatalities from native pitvipers (family Viperidae, subfamily Crotalidae, including rattlesnakes, cottonmouths, and copperheads) are quite rare. Furthermore, these snakes are not associated with causing paralysis.[5] They are primarily associated with causing tissue injury, and a growing body of recent evidence suggests that the amount of permanent physical disability occurring may be dramatically underestimated.[6] These factors significantly change the risk versus benefit considerations for domestic snakebites and appear to be the basis for the Wilderness Medical Society recommendation against using pressure bandage immobilization for bites by these snakes.

So, let's take a closer look at those 2010 American Heart Association and American Red Cross guidelines. Only two references were provided for their statement. The first was an experimental investigation of "the efficacy of pressure-immobilization bandages in delaying the onset of systemic toxicity in a porcine model of coral snake envenomation."[7] This was a puzzling reference to support pressure bandage immobilization in non-neurotoxic snakebites, considering the study used venom from the strongly neurotoxic Florida coral snake (*Micrurus fulvius*). In other words, it is NOT a "non-neurotoxic American snake" as suggested.

Copperhead (*Agkistrodon contortrix*)

Cottonmouth, also known as water moccasin (*Agkistrodon piscivorus*)

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The second reference was an experimental investigation of "the effect of pressure immobilization on mortality and intracompartmental pressure after artificial intramuscular *Crotalus atrox* envenomation in a porcine model." [8] We know all about the Western Diamondback (*C. atrox*) here in Arizona, as they have long been considered responsible for most of our envenomations. They are also the most widely distributed pitviper across the arid southwestern United States and are truly "non-neurotoxic American snakes." So, let's take a closer look at this study for ourselves. Lethal doses of venom were intentionally administered to anesthetized pigs and the authors found that pressure immobilization resulted in "longer survival, less swelling, and higher intracompartmental pressures." Measured compartment pressures in the subjects where pressure bandage immobilization was used were increased by 179%, which certainly sounds like a lot. When internal compartment pressures become high enough, the circulation of blood in the tissue becomes cut off. If circulation remains impaired for a prolonged period, it results in the potential to develop a critical limb or life-threatening complication called "compartment syndrome." When considering animal studies, it's important to remember that humans aren't pigs and things don't translate directly from animal models to humans, but at a minimum this raises some concerns. Especially when considering that snakebite deaths are rare in the United States, and the value of that "longer survival" observed is probably not going to translate to benefit for humans. The authors of this study reached the same determination. In their conclusion, they stated that "On the bases of our findings, we cannot recommend pressure immobilization widely for viper envenomation, although specific scenarios may warrant its use." They also suggest that an "informed decision" would have to consider other factors that might elevate the risk of death or severe systemic effects. Full disclosure: one of us (MC) was a coauthor on this second study.

Western Diamondback (*Crotalus atrox*)

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Following the surprising 2010 recommendation for using pressure bandage immobilization for non-neurotoxic bites in the U.S., a group of concerned individuals wrote a letter to the editors of *Circulation* (See Appendix 1) summarizing many of the issues we have just described, concluding with this statement:

> "The article gives the impression that pressure-immobilization is recommended for first aid treatment of pitviper bite, when in practice it is not and generally should not be in the US. In fact, there are no new data to suggest any deviation from the snakebite first aid recommendations made in the last edition of the Guidelines. We hope that you will correct the online copy of the Guidelines to this effect."

After several weeks, a response was received (See Appendix 2), stating that the letter to the editors would not be published. Furthermore, it stated that available evidence demonstrates that pressure immobilization "delays venom flow and decreases mortality" and that the "subsequent outcome of intracompartmental pressure rise was not known". Ok, technically speaking their response was accurate. However, it is a bit questionable to translate the benefit to humans from a reduction in pig mortality, when considering that human deaths are rare and thus mortality makes it a poor primary study outcome. Similarly, stating the absence of proof establishing harm from elevated compartment pressures due to venom induced injury is true, but is arguably a bit pedantic. Compartment syndrome is a physiology problem, resulting from impaired circulation regardless of the cause, with well-established sequelae. As far as we know, there is no reason to believe that venom is causing false elevations with the tools being used to measure the internal compartment pressure, which is exactly what would need to happen for us to consider elevated pressures from venom to be somehow different from other causes. Some things in medical research need to be accepted intuitively and not require definitive proof of harm by simply changing an unrelated variable and claiming it has never been established. For example, just because nobody has ever studied whether pedestrians getting hit by a bus do better when they were wearing red versus blue pants, doesn't mean that we can't recognize that pedestrians getting hit by a bus is always going to be a bad thing.

Local tissue damage from a "non-neurotoxic" bite to the left hand

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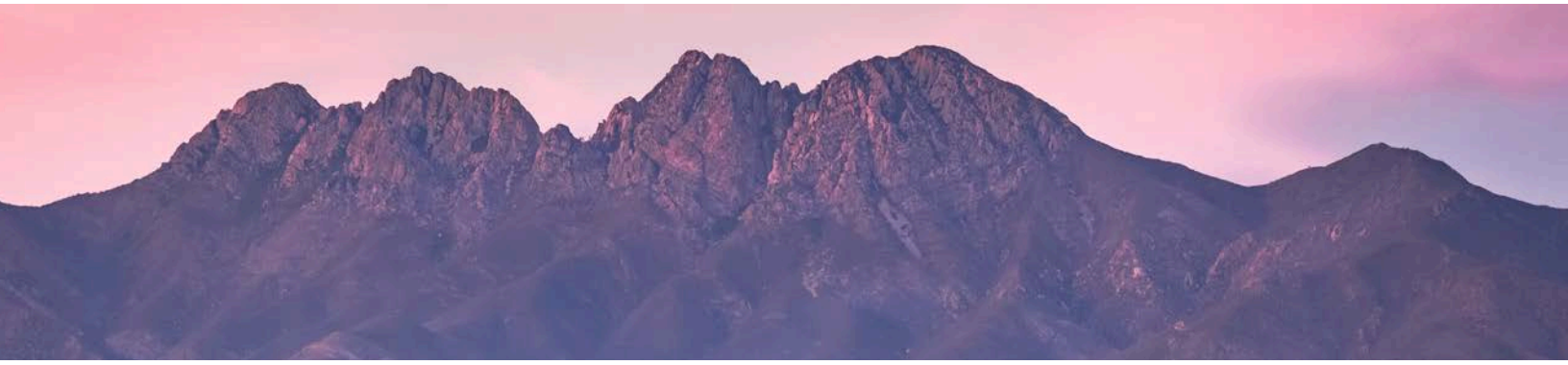
The editors' response also put forth a third reference as further evidence to support their position "that pressure immobilization prevented death in a porcine model from non-neurotoxic snake envenomation and surviving animals had full recovery of limb use." And it was here that concern for the situation really began to escalate. Not mentioned in the response by *Circulation* editors, but buried in the back of the additional paper they cited, was the mention that one of the three pigs receiving pressure bandage immobilization died twenty-five minutes after the pressure wrap was removed, when its potassium level spiked from 3.6 mEq/L to 10.7 mEq/L (normal is 3.0-5.0 mEq/L). Now, every emergency medicine provider reading this knows exactly what that means. But for those who don't, most of the potassium in our bodies is normally found inside our cells. When lots of cells die rapidly, their intracellular contents are released into the blood stream, and a huge spike in potassium occurs that can cause major problems for the way our heart muscle conducts electricity. In simple terms, the heart tends to stop pumping, and as you can likely imagine people tend to die shortly afterwards. This is the exact type of complication you would expect from a massive compartment syndrome and is arguably the proof of harm from pressure bandage immobilization that the editors were claiming didn't exist.

Thankfully, others were also paying attention and reviewing the evidence. In December 2011, a rebuttal jointly authored by six leading toxicological associations was published, directly opposing the American Heart Association and the American Red Cross recommendation by stating:

2011 American College of Medical Toxicology, American Academy of Clinical Toxicology, American Association of Poison Control Centers, European Association of Poison Control Centers, International Society of Toxinology, and Asia Pacific Association of Medical Toxicology:

> "Given that the primary toxic effect of envenomation is local tissue injury, mortality is not an ideal outcome measure to extrapolate to human crotaline envenomation. Available evidence fails to establish the efficacy of pressure immobilization in humans but does indicate the possibility of serious adverse events arising from its use. The use of pressure immobilization for the pre-hospital treatment of North American Crotalinae envenomation is not recommended."[9]



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Now remember, we began this newsletter by stating that the recommendation by the American Heart Association and the American Red Cross had just been changed in 2024. Let's look at what happened between the 2011 rebuttal just described, up until the end of 2024. As of early 2014, the online edition of Circulation (2010) still recommended pressure band immobilization for pitviper bites, but it had been amended by removing the coral snake reference while retaining the reference involving the western diamondback venom study. And pressure band immobilization continued to be recommended for pitviper bites in both the 2014 and 2016 versions of the *First Aid/CPR/AED Participant's Manual*. It wasn't until the 2021 version of this manual that the recommendation was changed to read:

> "Pressure immobilization bandaging, with the use of an elastic bandage, may be considered by those trained in proper application following the suspected bite of a coral snake in the United States if the transport time to hospital may be prolonged. However, pressure immobilization bandaging should not be used following the bite of a pitviper in the United States and Canada. Pitvipers include rattlesnakes, cottonmouths (water moccasins) and copperheads."

And finally, the most recent five-year revision of the American Heart Association and the American Red Cross first aid guidelines was published on 10 December 2024 with the language found at the beginning of this newsletter.

Let's conclude our discussion today by considering the impact of a saga like this. The American Red Cross has an extraordinary influence on first aid training and publications in this country, reporting nearly 3.8 million people trained each year in Red Cross First Aid, CPR and AED classes. Every year we see a small number of rattlesnake bite patients presenting to the hospital who have attempted to restrict venom absorption using things like hair ties, socks, and belts. Occasionally, we also see medical tourniquets that were applied by Emergency Medical Technicians on route to the hospital. The Arizona Poison and Drug Information Center monitors events like this as part of its public health surveillance mission. When they occur, the ambulance company responsible is contacted and a toxicologist is sent to provide education onsite for staff members. Misinformation and insufficient conceptual understandings have plagued published guidance documents regarding providing medical care to envenomated patients, and patients have suffered as a result. Dispelling that type of misinformation is exactly why News From the Pit was started.

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Letter to the Editor

Pressure-immobilization should not be recommended for most U.S. snakebites

Dear Editor:

We are concerned about inaccuracies published in a recent issue of your journal [Markenson et al., *Circulation* 122 (18 suppl 3) S934-S946]. [1]

For snakebites, this article states that applying a pressure-immobilization bandage is "effective and safe." However, the references cited do not support this assertion. Specifically the authors state, "the effectiveness of pressure immobilization has also been demonstrated for bites by non-neurotoxic American snakes." Neither of the two studies referenced corroborates this: one utilized venom from the coral snake, which is not a pit viper and produces neurotoxicity with insignificant local effects; the other (authored by several of us) showed mixed results with rattlesnake venom, including increased compartment pressures. [2,3]

Further we question the Level of Evidence the article gives these studies (Class IIa, LOE C), which are all simulated envenomations and/or animal models. We debate whether the benefit exceeds risk. Because death and permanent systemic injury from snakebite are rare in the US, and the predominant complications are permanent local sequelae, we do not advise restricting the dissipation of tissue-destroying venom away from the bite site. [4]

Other potential problems with the safety and efficacy of pressure-immobilization include the possibility of releasing a bolus of venom into the systemic circulation upon loosening of the wrap and the fact that walking stimulates the systemic spread of venom regardless of the bandage, even in upper extremity bites. [4,5]

The article gives the impression that pressure-immobilization is recommended for first aid treatment of pit viper bite, when in practice it is not and generally should not be in the US. In fact, there are no new data to suggest any deviation from the snakebite first aid recommendations made in the last edition of the Guidelines. [6]

We hope you will correct the online copy of the Guidelines to this effect.

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Regarding Perceived Discrepancy in Snakebite Treatment Recommendation:

We have reviewed this Letter to the Editor and appreciate your interest and concern over this issue. After consideration of the available literature, we do not feel that a correction is warranted.

As noted in the 2010 First Aid Consensus on Science and Treatment Recommendations (CoSTR) [1], the predominate body of science on properly performed pressure immobilization demonstrates that it delays venom flow and decreases mortality in simulated snake envenomation animal models, both in neurotoxic snake envenomations and non-neurotoxic snake envenomations. Bush, et al., notes that the mean intracompartment pressure rose in those animals treated with pressure immobilization, but the subsequent outcome of such a pressure rise was not known and proposes "a longer-term observation followed by an evaluation of functionality after a pressure immobilization-treated viper envenomation." [2] Since the time of the completion of the International First Aid Science Advisory Board's work on the CoSTR, another article authored by Meggs further demonstrated that pressure immobilization prevented death in a porcine model from non-neurotoxic snake envenomation and surviving animals had full recovery of limb use.[3] The Howarth study also concludes effectiveness of properly applied pressure immobilization but adds that "strict limb immobili[z]ation is necessary to minimi[z]e lymphatic flow, and walking after upper or lower limb envenomation will inevitably result in systemic envenomation despite first-aid measures."[4] No study supported your specific concern of a venom bolus, although further research into this area may be necessary. Overall, in the research available to date, survival is increased following properly performed pressure immobilization for the variety of snakes studied. All of the cited articles are appropriately individually classified in the CoSTR according to their Level of Evidence (LOE).[1] The final statement regarding pressure immobilization for snakebites included in the 2010 Guidelines for First Aid [5] received a Class IIa recommendation (benefit outweighs risk, additional studies with focused objectives needed) and LOE C (very limited populations evaluated), the lowest available LOE. The authors of the writing group discussed specific circumstances (significant envenomation, distance to care, etc.) where the benefit of lowered mortality as evidenced by the research, would outweigh the risk of elevated compartment pressure without evidence of permanent disability.

The primary debate remains whether lay public can "properly perform" pressure immobilization. As noted in the CoSTR, two studies showed that retention of the ability to perform proper pressure immobilization was poor. The "knowledge gaps" acknowledged in our manuscript clearly mirror these concerns. The published guideline is a comment on the available science, leaving specific training and therapy to be determined by various organizations, medical directors, and clinicians.

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