

Algorithmic approach to the prevention of unnecessary fasciotomy in extremity snake bite[☆]



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ABSTRACT

Background: In the literature, there is a lack of a consensus about the occurrence of the compartment syndrome due to the snake bites. There are different concepts for the surgical treatment of the threshold value of the chamber pressure. There are many different classifications and assessment criteria for the snakebites.

Purpose: There is not any appropriate classification in order to the assessment of extremity snake bites while making a decision for fasciotomy. We aimed to standardize the follow-up and decision making to perform fasciotomy with a new classification system for the snakebites using objective data.

Patients and methods: The data of all patients were recorded prospectively between 2006 and 2011. A total of 97 patients (64 male, 33 female) with a mean age of 30.94 ± 14.04 were followed-up. During the evaluation of the patients, we used a new classification system that was improved for the extremity bites. We classified the patients due to their signs into four groups as for the classification system.

Results: 40 patients with compartment like symptoms were carefully followed for 48–72 h, and only three patients required fasciotomy where full recovery was achieved in 37 patients. Coverage of the defects was performed with full thickness skin grafting in 4 patients and cross finger flap in two patient. In two patients, the defects were located on the palmar aspect of the thumb. Thus, we applied Kite flap for skin coverage. Reverse dorsal digital artery flap was performed in eight patients and dorsal interosseous metacarpal flap in six patients. Four patients underwent an amputation. Two patients had web reconstruction due to first web contracture.

Conclusions: We present a large series of snake bite injuries and propose a classification and treatment recommendations. Fasciotomy should only be done while the measurement of intra-compartment pressure is above 55 mm Hg as snakebite can mimic the compartment syndrome.

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Introduction

The nine of 10 snakes' species are composed of a rattlesnake from Viperidea family [1]. The snake venom contains lower molecular weighted peptides such as neurotoxin, cytotoxin, hemotoxin, glycoproteins, a vast number of enzymes such as

proteolytic, hydrolytic and hyaluronidase enzymes and metallic ions [2–4].

In the literature, there is a lack of a consensus about the occurrence of the compartment syndrome due to the snake bites [5,6]. The delay of the diagnosis for the compartment syndrome results with some degrees of ischemic contractures or limbs amputations [7]. There are many different classifications and assessment criteria for the snakebites, and most of them are used in emergency departments [8,9]. However, there is a lack of a guide classification for evaluating the snakebites while making a decision for fasciotomy.

In this study, we aimed to standardize the follow-up, decision making to perform fasciotomy and to decrease the morbidity with a new classification system for the snakebites using objective data.

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Methods

The data of all patients who admitted to the emergency department and outpatients were recorded prospectively between 2006 and 2011. All procedures were performed in accordance with the ethical standards of the Institutional Research Committee and with the guidelines set forth in the Declaration of Helsinki. Prior to enrollment, each patient provided written informed consent. Of the patients, 84 had appealed to the Medical Faculty Emergency Department in the acute period of snake bite and 13 were referred to Plastic Surgery Department for the tissue necrosis and joint contracture due to snake bites at the late period. Seventy patients killed the snakes; 40 patients brought the dead snake to the hospitals where they first had recourse to identification.

The wounds and snakebite sites of all patients were cleaned and dressed with sterile gauze that at the emergency service. All the patients were interrogated for the tetanus vaccine and the patients who did not receive tetanus vaccine for the last five years were vaccinated. The patients were followed up for local and systemic signs.

All patients admitted to the emergency room are given the first dose of antivenom treatment prophylactically to reduce the

complication rates. The European Viper Venom (Intervax Biological Ltd., Zagreb, Croatia) was used as the anti-venom. The antiserum contains antibodies against V. Ammodytes, V. Aspis, V. Berus, V. Lebetina, V. Ursinii and V. Xanthin species [10,11]. Regarding the severity of the symptoms, two or five flacons of the anti-venom were administered. Anti-venom was used in 100 cc Ringer's lactate solution by giving intravenously within 10 min. The antiserum administration was repeated due to the signs. If a traditional method was used for removing the poison such as sucking the poison, a combination of penicillin and metronidazole was administered.

The vital signs and the bite locations of all patients were evaluated. The patients were followed-up for a probable systemic reaction. Circumferential extremity measurements should be done immediately after snakebite to use for comparison. The comparison should be made by measuring the diameter of the contralateral limb when the patient comes later than 2 h of injury. Mannitol should be initiated in patients with local reaction signs as mild swelling or bruising at the bite site, mild systemic symptoms and whose extremity diameter increases over the 2 cm. If there was a suspicion for compartment syndrome, the compartment pressure

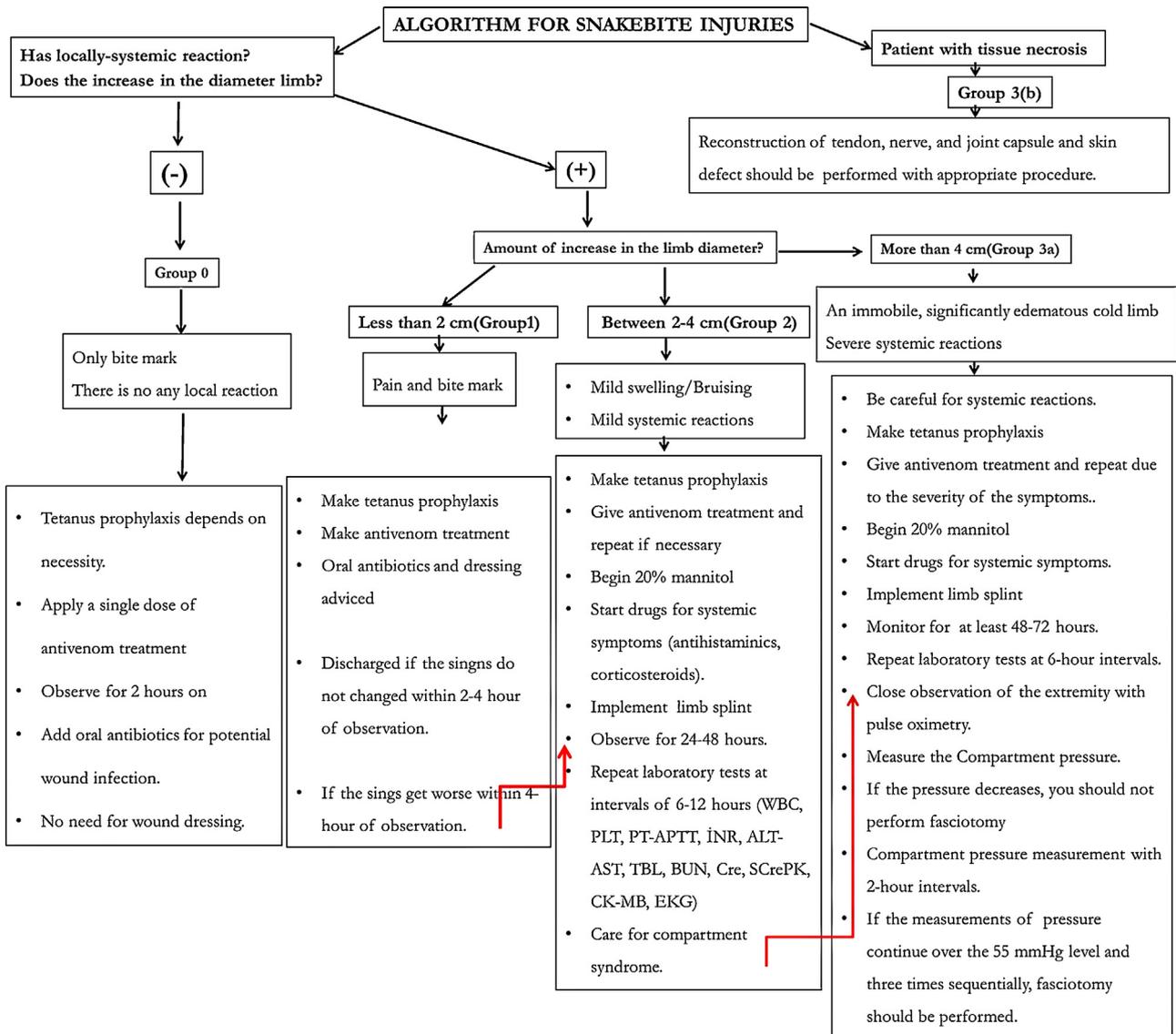


Fig. 1. Algorithm of Snakebite Injuries.

was measured. (The intra-compartmental pressure monitoring system, Stryker Corporation[®]).

We classified the patients due to their signs into four groups as for the classification system (Fig. 1).

Group 0

There is only a bite trace. There is not any local or systemic reaction. There is not any diameter increase of the extremity. Tetanus prophylaxis depends on necessity. The anti-venom therapy is administered that only a single dose of antivenom. By after a two hours follow-up period, the patient is discharged. There is no any recommendation for wounds.

Group 1

There is a pain with the bite mark. There is at least two cm increase of the extremity diameter. The tetanus prophylaxis is performed, and the antivenin therapy is administered. By after a 2–4 h follow-up period, the patient is discharged and immobilization with a splint if the findings are not that evil. Dressing is recommended for the wound. If the symptoms are not worsening in group 1 patients, the mannitol infusion is not recommended.

Group 2

There are local reaction signs as mild swelling or bruising at the bite site, and there are mild systemic symptoms. There is 2–4 cms increase of the extremity diameter. Tetanus prophylaxis is performed. Antivenin therapy is administered and may be repeated due to the severity of the symptoms. Additionally the infusion of 20% of mannitol may be used. The agents (antihistamines, corticosteroids) for decreasing the systemic symptoms of the antivenin may be used. The extremity splints may be used for elevation in group 2, and 3(a) patients and the circular cast are not recommended. The patients should be followed-up for 24–48 h period against probable systemic reactions. For the assessment of the systemic reactions the laboratory studies should be repeated to the 6–12 h intervals and an electrocardiogram should be taken. The physician should be taking care of in terms of the development compartment syndrome.

Group 3

Patients have the appearance of an immobile, significantly edematous cold, and apparently pulseless snake-bitten limb without (group 3a) or with tissue necrosis (group 3b) at the site of the bite. There is more than 4 cm increase of the extremity diameter in group 3a. Tetanus prophylaxis is performed. Antivenin therapy is administered at least two doses and may be repeated due to the severity of the symptoms. Additionally the infusion of 20% of mannitol may be used. The agents (antihistamines,

corticosteroids) for decreasing the systemic symptoms of the antivenin may be applied. The victim should be followed-up for 48–72 h period against probable systemic reactions. For the assessment of the systemic effect of poison, the laboratory studies should be repeated to the 6 h intervals, and an electrocardiogram should be taken.

Close observation of the extremity with pulse oximetry is obligatory, compartment pressures may be measured if necessary with the intra-compartmental pressure monitoring system (Stryker Corporation[®]). Once the diagnosis of compartment syndrome is clear, the surgeon should not hesitate to perform fasciotomy. Swelling starts at the site of the bite area and usually extends to whole extremity gradually in 6–48 h.

Results

A total of 97 patients (64 male, 33 female) with a mean age of 30.94 ± 14.04 were followed-up. Of these patients, the 78 patients were the farmer, and the rest were from different profession groups. The majority of the bite area (92 patients) were located at the upper extremities (fingers, forearm) and lower extremities (foot, heel, ankle, crus), only 5 patients were bitten from the other body parts. All 84 patients that appealed to the emergency service had received snake anti-serum (antivenin). Fifty-two patients needed a second dose, and 23 patients received the third dose of antivenin. There were four allergic reaction cases occurred after antivenin therapy. Three of these 4 patients, had mild urticarial rashes, 1 patient was followed-up for 48 h period at Intensive Care Unit (ICU) due to anaphylactic reaction and shock, after improvement of the symptoms the patient was discharged (Table 1).

At emergency service evaluation, the most common encountered local signs and symptoms were teeth mark, pain, ecchymosis, swelling, regional lymphadenopathy, paresthesia, swollen reactions, allergic reactions and the necrosis. While the systemic signs and symptoms were nausea, vomiting, tachycardia, fever, hypotension, unconsciousness, vertigo and blurring of vision (Table 2).

53 of all patients were hospitalized by Plastic Surgery Department after initial evaluation during the acute period. Of these patients 40 of them were followed up for a 48–72 h period because of compartment syndrome-like symptoms, all of these patients responded to 20% mannitol and antivenom therapy and by the release of the symptoms and decrease of compartment pressure. Of these patients 10 of them were followed up for a 96–120 h period three of them required fasciotomy. We set the upper limit of compartment pressure of 55 mm Hg [12]. After the first 96 h of hospitalization and the compartment pressure measurements in muscle belly of these patients repeated within 2 h intervals for at least three times. In addition, the failure to obtain the pulse with hand Doppler. The compartmental pressure was between 55 and 65 mm Hg in 3 patients thus fasciotomy was performed, because pressure tends to increase. After 7th to 9th days of fasciotomy, the fasciotomy defects were closed by primary

Table 1
Demographic characteristics of the snake bite victims (n=97).

	n	%
The mean age	30.94 ± 14.04	
Sex, male/female	64/33	65.9/34.1
Farmers or shepherds	78	80.41
Other professions	19	19.59
The patients who admitted to the polyclinic after the acute phase	13	13.41
The patients who were followed from the time of first contact with the emergency	84	86.59
The number of upper and lower extremity snake bites	92	94.84
The number of snake bite in the other regions	5	5.16
The number of allergic reactions due to snake anti-venom	4	4.12
The total number of patients	97	100

Table 2
Local and systemic manifestations of patients in the emergency department.

Local	n ^a	% ^a
Fang marks	84	100
Pain	78	92.85
Ecchymosis	76	90.47
Swelling	75	89.28
Swelling of regional lymph nodes	22	26.19
Paresthesia	8	9.52
Swollen reactions	4	4.76
Allergic reactions	2	2.38
Necrosis	24	28.57

Systemic	n	%
Nausea	54	64.28
Vomiting	35	41.66
Tachycardia	15	17.85
Fever	17	20.23
Hypotension	18	21.42
Fainting or dizziness	8	9.52
Blurred vision	2	2.38

^a Only patients in the emergency department.

Table 3
Classification of patients with snake bites in the extremities into four groups.

Groups	n(97)
Group 0	3
Group 1	11
Group 2	30
Group 3 (a)	27
(b)	26

closure in one patient and skin grafting in remaining two patients. The common feature of patients who underwent fasciotomy were admitted after the second day of the bite and antivenin and mannitol were initiated at late period of bite.

The patients who appealed to the emergency service at acute period and who were referred to plastic surgery department at the late period were grouped as for our classification system and the groups 0, 1, 2, 3a and 3b were contained 3, 11, 30, 27 and 26 patients respectively (Table 3).

Four patients who admitted with the late stage of bite (2 patients with the 2nd finger DIPJ level, two patients from 3rd finger PIPJ level) underwent amputation and stump closure because of the obvious tissue necrosis. Four patients had superficial defects, so the defects were closed by full thickness skin graft (FTSG) harvested from the groin region. The defects of 14 patients were closed by a reverse dorsal digital-metacarpal artery island flap (8

patients dorsal digital flap, six patients dorsal metacarpal artery flap). 3 of these 14 patient had lateral collateral ligament reconstruction for PIPJ, 3 patients had digital nerve repair by antebrachial cutaneous nerve graft, 3 patients had arthrodesis, simultaneously. 2 patients have defects on the palmar aspect of the thumb, so Kite flap was used for reconstruction. The defects of two patients were reconstructed by cross finger flap. Two patients were suffered first web contracture after the 6th month of the bite. For these patients, a bone graft from the iliac crest was used for web reconstruction, to enhance the web space. Nevertheless, all patients were successfully treated and recovered completely. There were no deaths (Table 4).

Discussion

The Snakebites usually affect the extremities but in the literature, the classifications mainly interested in the systemic symptoms and emergency service interventions [8]. All of these classifications are adjusted mostly due to presence and severity of systemic symptoms and enable the surgeon to decide the appropriate management of general envenomation of snakebite. Snakebite of the extremity with no systemic effects requires a specified and distinctive classification to follow up patient correctly and to perform an appropriate treatment. For this reason, we classify the snakebites to extremity into four groups only regarding the severity of local symptoms in the affected limb. In this study, the patients whom suffered from snake bites and appealed to the hospital were evaluated by a new classification system and the cases were determined for composing a new algorithm for the interventions in terms of acute and late periods of snake bites. This classification system is practicable to all snakebite situations and may help to determinate the compartment syndrome in the absence of the compartment pressure measurement devices. If there is a suspect for compartment syndrome, it offers us to have an objective determination by measuring the compartment pressure. Additionally, it reduces the mistake risk of the health staff and provides ideas to the trainee in terms of intervention for the about snakebites.

The toxicity of a snake bite depends on several factors in terms of the species of the snake, the injected poison proportion, and its protein ingredients, the number of bites, the age of the bite victim, the bite site, the hypersensitivity against the poison, the systemic chronic diseases of the victim such as diabetes, hypertension, coagulation disorders [1,13]. In the bite cases, it is not always possible to determine the species of the snake. Due to the death risk, all of the snake bites should be considered as a poisonous bite [14,15]. The species of the snakes could be detected correctly in only of 40 the patients who admitted to our clinic and for other

Table 4
Surgical interventions.

	n(97)	%
Fasciotomy	3	3.09
Amputation	4	4.12
Grafting	4	4.12
Reverse dorsal digital-metacarpal artery island flap	14	14.43
Kite flap	2	2.06
Cross finger flap	2	2.06
Lateral collateral ligament reconstruction	3	3.09
Digital nerve repair with nerve graft	3	3.09
Arthrodesis	3	3.09
First web reconstruction with bone graft	2	2.06
Total number of surgical intervention required patients	31	31.95
"only-follow-up" patients	29	29.89
Number of the patients with compartment syndrome-like symptoms	37	38.14

patients we planned the treatment as to the most common snake species. The snakes bites are seen at farmers and male outdoor workers as compatible with the literature [14]. More than the 94.84% of the patients are suffered of upper and lower extremities. The patients who admitted to the hospital in our region is thought to be less than the actual number of the patients because most of the patients are still tried to be treated with traditional treatments [16]. Al et al. reported that the bite of *V. Ammodytes* species causes mild local and systemic reactions, and most of these symptoms are resulted from misapplications [1]. We also encountered increased complication rates due to these kinds of traditional misapplications.

In the literature, there are different concepts for the surgical treatment of the threshold value of the chamber pressure [6,17]. There are some studies that advocates postponing the fasciotomy into the last stage otherwise the fasciotomy may lead to the vast majority of the complications [5,12]. Thus, it is advised to elevate the extremity and to administer medications like mannitol infusion until the onset of the clinic signs of the compartment syndrome. Controversially, some studies advocate a close follow-up of and also it is stated to perform fasciotomy if there are clinical fears [17,18].

Cawrse et al. reported that compartment syndrome developed three days after the bite, and thus they performed fasciotomy in a snake bite case [19]. Therefore, the cases of extremity bite victim should be under close follow-up and for a full functional recovery the fasciotomy should be performed [20,21]. McQueen and Court-Brown reported the threshold value of the compartment pressure for fasciotomy as 30 mmHg [22]. In their study, Firat et al. suggested that early period fasciotomy enhanced the circulation of the extremity as well as clearing the toxins [23]. However, the authors stated that they did not measure the compartment pressure in any of their patients and in 6 patients they performed fasciotomy within the first 48 h while there was no sign of compartment syndrome.

Most of the snakebites mimic the symptoms of compartment syndrome [24–30]. The fasciotomy is advised for only the cases of increased compartment pressures that are obtained by measurement [31]. Additionally many authors report that the most of the symptoms of the compartment syndrome regress by antivenom therapy [26,32] and if there is a progressive compartment pressure over 30 or 40 mmHg, then the fasciotomy should be considered [26]. The earlier fasciotomies increase the morbidity [32].

Brendan et al. reported that only two patients required fasciotomy within ten years [33]. Chew et al. said only one patient required fasciotomy due to compartment syndrome [14]. Gold et al. reported that despite of the 55 mmHg of compartment pressure, by the administration of antivenom, 20% mannitol and hyperbaric oxygen therapy they achieved a pressure decrease without performing a fasciotomy, and they report a total recovery of the patient. However, also they report that the patient had reactions due to anti-venom at the late period [12]. In patients with group 2 and 3 (a) should be initiated mannitol. Unnecessary fasciotomy is blocked with the use of mannitol. 40 of our patients presented compartment syndrome like symptoms but only three patients underwent fasciotomy despite of mannitol and antivenom therapy. The invasive interventions which results with aberrant scarring as like fasciotomy should not be determined at early period.

Tanen et al. reported an experimental study that antivenom alone is superior in outcome to either fasciotomy or antivenom plus fasciotomy, regardless of tissue/compartment pressures. In their study, a statistically significant amount of muscle necrosis for the fasciotomy group. Additionally they reported the ineffectiveness of the antiserum for the muscle necrosis [5]. The myonecrosis may depend on the toxic effects of the snake venom proteins that

directly cause necrosis without increasing the compartment pressure, there are some supportive studies for this data in the literature [25,29,32]. However, the limiting factors of this study are the design of the study for 8 h and the injected amount of the venom for a particular dose (12 mg/kg). In other words, the observation time is too short to determine the reactions of the body to the venom. Additionally, depending on the snake species, the injected amount of the poison for one bite varies according to many other parameters. Fulton et al. [34] criticized the study of Tanen et al. from the aspect of performing the fasciotomy despite the lack of compartment syndrome and determined it as a lack of study design, also while Tanen et al. determined that anti-serum was not an effective therapy method. However, it was the current treatment approach, and it could not be generalized to human beings. We think that fasciotomy is a scarring and invasive procedure so that, it should be performed after the measurement of compartment pressure in the presence of the signs of compartment syndrome. For the other processes (burns, bone fractures) that causes compartment syndrome, the pressure measurement and clinic signs may be mandatory but for the compartment syndromes due to snake bites after administration of all medical and prophylaxis these criteria should be determined as secondary choice.

Cumpston had reported a review of the 99 articles printed in the literature about the Crotalinae snakebites, he reported that the administration of the fab antivenin had decreased the compartment pressure and had enhanced the tissue perfusion; additionally he had determined that the fasciotomy procedure was not found useful due to its increasing effect of tissue necrosis. He stated that current literature supports Fab antivenin administration and despite the increasing effect of Crotalinae snakebites over the compartment pressure, the fasciotomy and dermatome should not be performed [35]. In a similar study, Toschlog EA had reported that the serial determination of the parenteral analgesic administration, antivenom therapy and the affected extremity should be done besides the laboratory tests. The parenteral anti biotherapy is not recommended whether the inflammation of soft tissues. He reported that the vast majority of the patients were recovered by antivenom and supporting therapy [36]. Our results are similar to the reports of the authors. But we think that our study may be a guide for learning curve period practitioners.

While the 40 of our patients presented compartment syndrome-like symptoms, their compartment pressure measurements revealed over the 55 mmHg and by administration of mannitol, and antivenom the symptoms of 37 patients resolved without fasciotomy. Only three patients whose compartmental pressure was between 55 and 65 mmHg. These 3 patients did not reveal and decreasing of compartment pressure thus the fasciotomy was performed.

As like as the other studies in the literature the species of all the snakes could not be determined in this publication. The antivenin our use is not available in all countries. Therefore, our algorithm would be modified in different locations that have access to that particular antivenin. Because of this study is a single institutional experience of extremity snakebite, the data cannot be generalized for all country in terms of epidemiology.

Management of a snake envenomation is species specific. Different snakes have differing toxicities, and therapy must be individualized. The response of the body against the poison induced reaction effects the compartment syndrome development and the severity of the process or vice versa. If there is a suspicion about the compartment syndrome development, these cases should be in the close follow-up. Additionally, the final decision should be given after the measurement of the compartment pressure if there is no regression of the signs of compartment pressure despite the antivenom therapy, mannitol infusion,

antihistaminic administrations. The delay of the diagnosis for the compartment syndrome results with some degrees of ischemic contractures or limbs amputations [7]. Complications of fasciotomy can be reduced using objective data.

Conclusion

In conclusion, the initial management of snakebite to extremity involves close observation of the local and systemic effects of envenomation at least two hours. Patients with local reaction such as swelling and bruising should be monitored for minimum 24 h and should have attention to occur compartment syndrome or tissue necrosis.

Fasciotomy should only be done while the measurement of intra-compartment pressure is above 55 mm Hg, and the increasing trend as snakebite can mimic the compartment syndrome. We present a large series of snake bite injuries and propose a classification and treatment recommendations.

Conflict of interest

All authors declare that there is no any conflict of interest. Each author certifies that he has no commercial associations (e.g., consultancies, stock ownership, equity interest, patent/licensing arrangements, etc.) that might pose a conflict of interest in connection with the submitted article.

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