General

Today there are around 1400 species of scorpions, although estimates of the exact number vary widely. All scorpions are venomous, but only a minority twenty five or so are potentially lethal for humans. Scorpions do not bite. Stings by scorpions are fairly common. Every year, more than 1 million cases of scorpion envenomation are reported worldwide. However most clinical reports emphasize the serious cases and systematically overestimate the danger these creatures pose. In endemic areas, people don´t go to a doctor for minor stings. Fatal stings are essentially limited to Mexico, Brazil, Trinidad, northern Africa, South Africa, the Middle East and India. It is primarily children and patients suffering from a respiratory and/or cardiovascular condition who run a high risk of complications.

Biology

Scorpions are the most primitive members of all Arachnida. Their sting is used to kill prey, for defence against aggressors and in some species it also has a role in the courtship display. Some scorpion species are long (*Hadogenes troglodytes* up to 21 cm), others are heavy (*Pandinus imperator,* also called the Emperor scorpion; *Heterometrus* sp.), while others are small (*Microtityus waeringi*, adult 12 mm). All scorpions are exclusively carnivorous. A scorpion first grasps its prey (generally insects) with the pedipalps. If the prey is not immediately overpowered, they sting it by bending the tail forwards over the body. The venom is actively injected. The scorpion releases gastrointestinal juices over the prey in order to liquefy it and later suck it up. They consume only the body fluids and liquefied tissues of their prey. A meal can last several hours. Some species are cannibalistic.

Because many scorpions live in dry environments, they have become adapted to minimize loss of water. This is made possible in part by a watertight cuticle based on chitin. This has unusual optical characteristics. Scorpions fluoresce with a greenish colour under long-wave UV light. This makes them easy to spot at night with the aid of a UV lamp. The reason for this fluorescence is unclear.

Taxonomy

Taxonomy, families

Buthidae: virtually all medically important species belong to this family. However, it includes nearly one-half of all scorpion species (around 600 known species). Buthidae have a triangular central plate, whilst the other families have a pentagonal sternum.

Bothriuridae: unimportant

Chactidae: unimportant

Diplocentridae: unimportant, except for *Nebo hierichonticus*

Scorpionidae: unimportant, except for *Hemiscorpion lepturus*

Vaejovidae: of limited importance. *Vaejovus* sp. and *Hadrurus* sp. can cause painful stings; but the effect is always local and limited.



Tityus serrulatus. Yellow scorpion endemic in parts of Latin America. Copyright ITM



Scorpion. *Parabuthus granulatus,* from Namibia. With special thanks to Prof Verdonck, Kortrijk.

Distribution

Virtually all lethal species belong to the Buthidae family. These animals are found primarily but not exclusively in dry areas. In the Buthidae family, the medically important and dangerous genera have the following distribution:

Androctonus	from Morocco and Senegal eastwards to India
Buthus	Mediterranean, Middle East and East Africa
Hottentotta	Northern Africa and the Middle East
Leiurus	East Africa and the Middle East

Parabuthus	from Sudan to South Africa
Mesobuthus	India, Southern and Central Asia
Tityus	South America
Centruroides	USA, Mexico, Central America

The most important species are:

- *Buthotus tamulus*
- *Leiurus quinquestriatus*
- *Androctonus crassicauda (and A. australis)*
- *Tityus serrulatus*
- *Centruroides suffusus*

Scorpion venom

Scorpion venom is a mixture of various active substances, but generally the neurotoxins are the most important. The neurotoxins are small proteins. Alpha neurotoxins inhibit the closing of sodium channels, without interfering with the opening potential. They lead to a strong membrane depolarization and hence, neuronal excitation. In a second phase loss of excitability is possible. Beta neurotoxins open Na^+-channels. Sodium is primarily an extracellular ion, and is necessary inter alia for maintaining an electrical voltage difference across the cell membrane. When the Na^+-channels open, sodium flows into the cell which depolarises the membrane. The nerves fire non-stop. The clinical effects of alpha and beta neurotoxins are similar. There follows a massive release of neurotransmitters, both acetylcholine and noradrenaline from nerve endings and adrenaline from the adrenal medulla. The main part is formed by the catecholamines, thus sympathetic effects usually outgo the parasympathetic effects.

Scorpion venom also contains serotonin, which contributes to local pain.

Clinical aspects

General

Most scorpion venoms contain little or no cytotoxic enzymes, so that a sting produces little local tissue damage. An exception to this is the cytotoxic venom of *Hemiscorpius lepturus*, a scorpion from Iran. Their stings are characterized by erythema and purpuric and bullous lesions that resolve, but in about 20% of cases there is delayed localized necrosis. Companion features include nausea, vomiting, fever, minor autonomic effects, direct haemolysis with haemoglobinuria and acute kidney injury that might necessitate dialysis. Bites by loxosceles spiders can mimic a similar clinical syndrome.

There are four factors which play a role in defining eventual symptoms: the quantity of venom introduced and its toxicity as well as the size and medical condition of the victim. Many scorpions without medical interest have venom that can kill a mouse, but when introduced into human beings only produces symptoms analogous to those of a bee sting. If there is an allergy to this venom, anaphylaxis can follow and death can result from a sting of even a “harmless” scorpion. Stings without injection of venom do occur (“dry” stings).

Local effects

Rapidly developing pain at the site of the sting is characteristic. Swelling and local redness are often limited but can be quite serious. Local necrosis is exceptional. Local paraesthesias can occur. Several South African scorpions can squirt venom up to one metre away. If this comes into contact with the cornea, chemical keratitis with burning pain develops.

Systemic effects

There are 3 main mechanisms of action: adrenergic (sympathic) excess, cholinergic (parasympathetic) excess and neuromuscular excitation. The adrenergic effect results in tachycardia and hypertension as well as mydriasis, agitation, seizures and myocarditis. The cholinergic effects are bradycardia and hypotension, vomiting, transpiration, salivation, lacrimation, miosis and bronchial spasms with excess secretions. The neuromuscular

excitation can lead to oculomotor abnormalities, visual disturbances, muscle spasms and eventually paralysis. Complications are cardiac arrhythmias, myocardial depression with pulmonary oedema, hypotension and shock. Death can be caused by respiratory failure or by coma and multiple-organ due to shock.

Symptoms can either develop quickly, within ten minutes, or – more rarely – slowly, after only 24 hours. More and more, doctors use a clinical gradation:

Degree 1: local effects only

Degree 2: autonomic excitation, agitation and anxiety

Degree 3: pulmonary oedema, hypotension and cardiogenic shock, severe neuromuscular excitation

Degree 4: multi-organ failure, coma, seizures, end-organ failure secondary to hypotension

Evolution from degree 1 to degree 4 can occur very quickly (sometimes within half an hour). Generalized fatigue with muscle stiffness and weakness, anxiety and restlessness are frequent. The tendon reflexes are hyperactive. Sometimes fasciculations, tremors and/or clonus develop. Other complication from scorpion stings include pancreatitis, rhabdomyolysis, diffuse intravascular coagulation and priapism.

Children are generally very restless, with crying and shouting, agitation, shaking, twisting and swinging of their limbs. The child cannot sit still. Mortality depends largely on age. Children, the elderly and people with a serious pre-existing medical condition have a substantially higher risk of death than adults.

Diagnosis

The diagnosis is essentially clinical. Due to the quick and intense local pain, the scorpion is often noticed. Yet the typical victim is someone who is usually stung at night in the foot, outdoors, possibly when he/she has moved a stone or some wood. People are also stung in

the morning when they try to put on a shoe in which a scorpion is hiding. Occasionally in North Africa men are stung in the genitalia when they urinate against an object while squatting. The laboratory often shows leukocytosis, hyperglycaemia and a transient increase of the pancreatic and cardiac enzymes. The ECG can display temporary ischemic deviations. Investigations should focus on potential complications of scorpion envenomation.

Scorpion stings, differential diagnosis:

1. Spider bite by *Latrodectus mactans* (black widow). The bite of the female spider produces little local reaction, contrary to bites by *Loxosceles reclusa*, yet is characterized by marked abdominal muscle rigidity, pain and excessive sweating. Dysphagia, sialorrhea, vision impairment and generalized hyperesthesia are generally absent with these spider bites. In South America, bites by *Phoneutria* spiders need to be considered.
2. Overdoses of neuroleptics, anticholinergics or tricyclic antidepressants. Generally these products do not produce excessive salivation and there is no local pain.
3. Organophosphate poisoning causing inhibition of acetylcholinesterase, leading to a buildup of acetylcholine. These insecticides also cause agitation, restlessness, muscle weakness, muscle fasciculations, hypersalivation, diarrhoea, miosis, transpiration, tachycardia and respiratory difficulties. However there is no pain.
4. Tetanus, botulism, diphtheria, meningitis and encephalitis can cause similar symptoms.
5. Neurotoxic snakebite.
6. Thyroid storm, carcinoid or pheochromocytoma.

Treatment

Patients with systemic symptoms must be hospitalized for 24-48 hours, preferably in an intensive care unit. Cardiac arrhythmia, hypertension and respiratory problems must be monitored. The airways must be kept open. Administration of oxygen and artificial respiration can be necessary.

Pain relief with powerful analgesia is often required. Local application of ice can reduce the pain, but may not be tolerated due to hyperaesthesia of the skin. Opiates should be avoided because of the danger of respiratory depression. Sometimes simple infiltration of the sting site with 2% xylocaine (i.e. lidocaine without adrenalin) can reduce the pain. The general

management is aimed at neutralising the effects of the overstimulation of the autonomous nervous system. Hypertension is counteracted by giving the vasodilator prazocin (alpha-blocker, Minipress®) or nitroglycerin if there is pulmonary oedema. Atropine is sometimes used as a parasympatholytic agent, but can aggravate orthosympathic symptoms, so usually it is preserved for bradycardia associated with hypotension. In case of neuromuscular incoordination or convulsions diazepam IV should be given. Inotropes (e.g. dobutamine) and diuretics (furosemide) are indicated if there is heart failure. Hyperthermia requires cooling and salicylates.

Most cases improve without antiserum within 9-30 hours (except for pain and paresthesias). In the event of severe envenomation, death frequently occurs within 6 hours after the sting. When systemic symptoms or autonomic excitations is present, IV antiserum is recommended. It should be diluted and administered in an IV infusion over 20-30 minutes. The dose is not age-dependent. Antivenom is expensive and guidelines often suggest and that its use should be restricted to cases of severe envenomation. However, once severe envenomation has developed, the administration of antivenom may be less effective, since its primary therapeutic action is to bind toxins; it does not reverse established pathophysiological injury, such as excess levels of catecholamine, pulmonary oedema, and cardiogenic shock. Antisera are good for neutralizing neuromuscular effects but have little effect on pain or paraesthesias. A type III hypersensitivity reaction can develop after administering the antiserum (horse, donkey or goat serum; see treatment of snakebites). Type I reaction (anaphylaxis) is exceptional. Tetanus vaccination must be checked.

Antitoxin:

USA and Mexico	anti-*Centruroides*
South America	anti-*Tityus*
South Africa	anti-*Parabuthus*
Maghreb	anti-*Androctonus* and anti-*Buthus*
Egypt and Israel	anti-*Leiurus* (also active against Androctonus crassidauda)
India	anti-*Mesobuthus*

Prevention

Firstly reduction of the places of shelter and the food supply of the scorpions. Insecticides are only effective in the sense that they eliminate the prey of scorpions. There is often insufficient contact between the body of the scorpion and the insecticides to be directly toxic. Natural enemies of the scorpions include cats and solpugids (alias camel spider). Of course, a house cat is no guarantee that there will be no scorpions in or around a house. It is recommended to clear away junk, loose wood etc. (fewer hiding places). The same applies for certain types of vegetation (e.g. *Opuntia* cactus hedges in northern Africa). Cracks and crevices in and around the house must be sealed. In endemic areas it is best to always shake out shoes before putting them on and to examine clothes and blankets before using them. It is prudent to also check the toilet before use. At night, scorpions can easily be detected with an UV-light.