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## JELLYFISH ENVENOMATION WHAT DIVING MEDICAL PHYSICIANS SHOULD KNOW

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### JELLYFISHES

The following species have been studied to date: the mauve stinger, hair jelly, Portuguese man o'war, cubomedusae (Figure 1) (including *Chirodropids*), North American sea nettle, and cabbagehead jellyfish. Their distribution is world wide. They are found mainly in salt water, in all oceans and seas and are more numerous in the tropics.

They envenomate those who use the sea, fishermen, divers and tourists, and marine scientists. Children are particularly susceptible (Figure 2). The *Chirodropids* (many-tentacled box jellyfish) (Figure 3) cause the majority of presently recognised human fatalities (Figure 2). However 2 recent confirmed fatalities in the U.S.A. from Portugese man o'war have occured, in Florida and North Carolina.

### JELLYFISH VENOMS

These are complex mixtures of polypeptides and enzymes. They include acid and alkaline proteases (elastase, DNase, collagenase, metallopeptidase), haemagglutin, and histamine[3]. The venoms damage humans locally and systematically. They act by both toxic and antigenic mechanisms. The former predominates. The toxins are of high molecular weight in the range 10,000-600,000[6]. There are some labile components; for example there is loss of toxicity from heat (37°C), storage, and some fractionation processes.

### HUMAN SEROLOGICAL RESPONSE[4]

Specific IgG serum concentrations appear within a few days following envenomation. IgG titres persist for many months. Reasonable (and improving) correlation is possible between clinical and serological identification of envenomating jellyfish. However significant cross-reacting antibodies do occur to the venoms of other jellyfish.

Titre levels of 1 in 50 are significant. Titres of 1 in 3000 are seen not infrequently. Elevated IgG titres are not protective against the cutaneous pain of jellyfish sting. There is some IgM response, but it is weaker than the IgG response. Following jellyfish envenomation, immunological reaction[1] occurs in both the B and T cell systems.

### LETHAL MECHANISMS [1,2]

The pharmacology of jellyfish venoms is largely unknown, possibly they are cell membrane destabilisers. Deaths are mainly toxic, however some are allergic due to anaphylaxis.[5] The toxic deaths are possibly combinations of myocardial toxicity[5,6], central neurological toxicity, and hypoxia from pulmonary effects.[8] Other severe toxic effects include gangrene (Figure 4), renal failure and haemolysis.

Anaphylaxis has been documented for a mauve stinger envenomation[5], and suspected for the Portuguese man o'war or blue bottle. Suggestive evidence is that basophils release

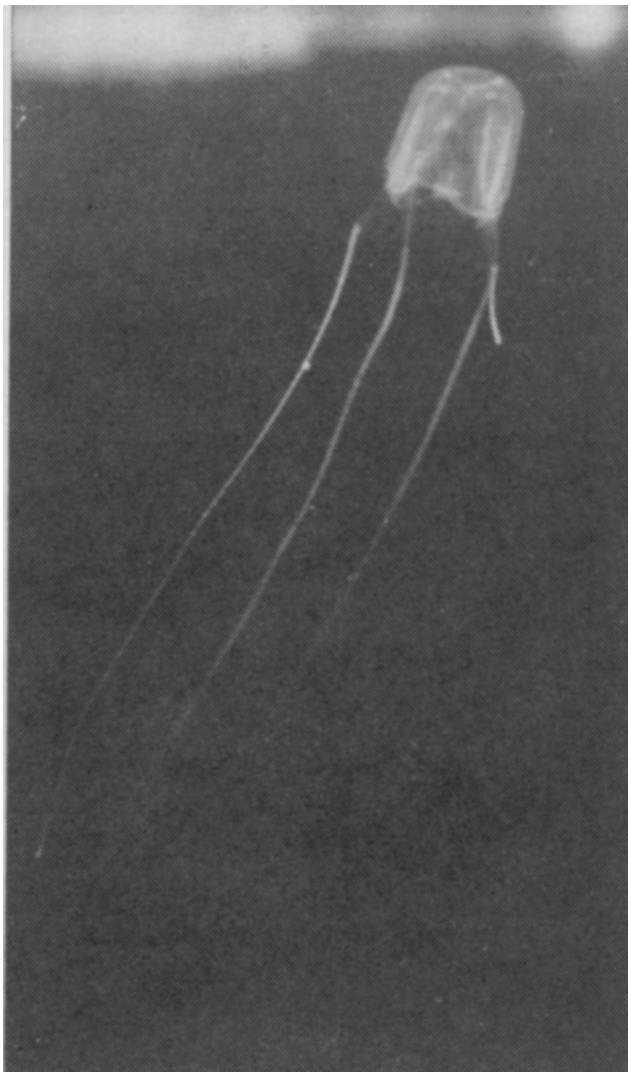

**FIGURE 1**

A Cubomedusa of the "Irukandji" type (one of the 4 tentacles broken during capture). Divers are at risk from the sting of this group of open water jellyfish. The syndrome may mimic decompression sickness.

histamine in response to venom challenge; sensitivity was passively transferrable in serum, which may have been an unrecognised cause of deaths in the past. Anaphylaxis is more likely in "sensitised" individuals, e.g. those with asthma or allergies.

Venom absorption in jellyfish stings is the most rapid known. This is due to multiple (millions) simultaneous microdoses into dermis. This presents a huge surface area. There may be some direct intravascular deposition. Capillary absorption is enhanced by the muscle pump action of movement. It is not certain that absorption can be stopped by compression/immobilisation bandaging. All other venoms (snakes, spiders, and insects) are absorbed by a combination of vascular and lymphatic capillary flow. The role of lymphatic absorption in jellyfish venoms is unknown at present.

CLINICAL FACTS

Skin reactions to stinging

Cutaneous pain is immediate, and usually severe. The skin pain is savage in *Chirodropid* stinging. There is erythema, blistering (Figure 5), and desquamation. Full thickness skin death may occur. There is increased vascular permeability leading to oedema. Serotonin inhibitors (methysergide) and leukotriene inhibitors (piripost) reduce cutaneous vasopermeability in animals. Initially there are always adherent nematocysts and occasionally adherent tentacles.

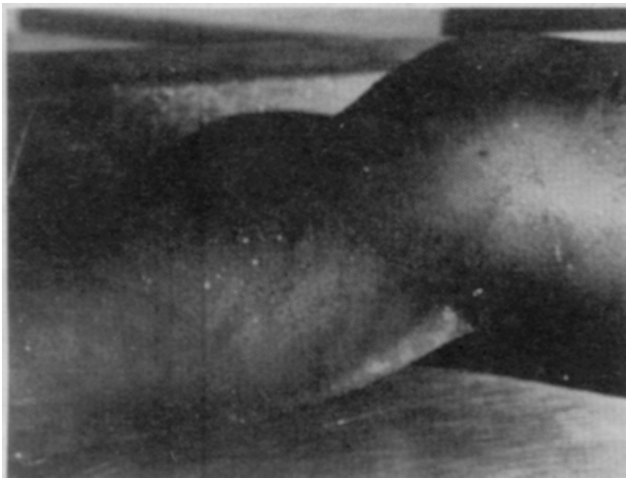

**FIGURE 2**

A post-mortem photo (12 hours) of a 4 years old aboriginal boy fatally stung by the chirodropid *Chironex fleckeri*. The identity of the jellyfish was confirmed by adherent tentacle and skin scraping examinations. Sadly, the majority of on-going jellyfish fatalities in Australia are now aboriginal children who inhabit remote tropical coastlines *(Photo courtesy of the late Dr Jack Barnes, Cairns)*.

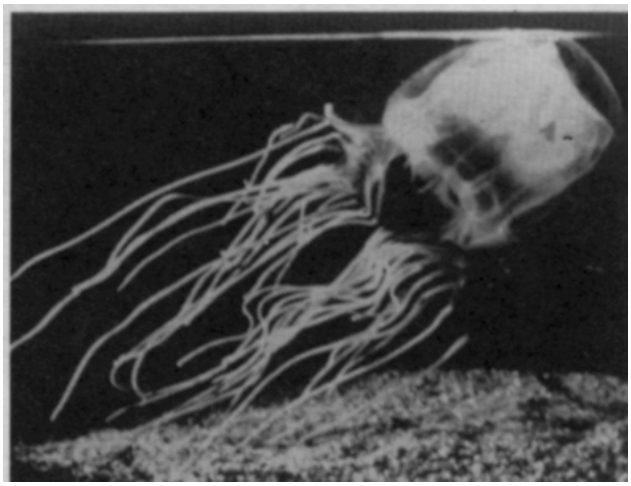

**FIGURE 3**

An adult chirodropid *(Chironex fleckeri)* under artificially clear conditions, showing the massive armament of tentacles, each laden with millions of venom bearing nematocysts. Entanglement in these by a careless swimmer, or bare-skinned diver produces the most explosive envenomation process presently known. Nematocysts cannot sting (envenomate) through any clothing, including a wet suit, or "stinger-suit".

Cardiovascular responses

These include hypertension, and hypotension, arrhythmias, which may be decreased by $Ca^{++}$ channel blockers. There is myocardial electro-mechanical dissociation[7] and it is said that the heart may arrest in systole.[6] The increased capillary permeability can affect the pulmonary vascular bed leading to pulmonary oedema, which can also be cardiogenic[8]. Local arterial spasm can cause distal gangrene. Apaper on this subject is in preparation.

C.N.S. Effects

Venoms do not cause neuromuscular blockade, nor convulsions. There is impaired consciousness, and respiratory arrest with subsequent hypoxia has been reported. The peripheral pain in "Irukandji syndrome" may be neural. The massive hypertension with Irukandji may be due to catecholamine surge[8].

Resuscitation

In all cases one should not give up resuscitation prematurely as many attempts have been successful. Sometimes expired air resuscitation only is required. The role of specific antivenom *(Chironex)* in potentially lethal *Chironex* stings is at present under examination, but it probably helps. Short-lived venom action is probably due to heat lability. Calcium channel blockers may help the myocardium; calcium will not[7]. Antivenom specificity will improve in the future, for life threatening stings.

Analgesia

Skin pain is eased by direct application of ice. It is also unquestionably relieved by the specific antivenom for *Chironex*. Intravenous narcotics are used non-specifically (e.g. for the muscle pains of Irukandji envenomation) require expert medical supervision. Evaluation of pain relief is confounded by placebo responses and is inadequate at present.

STILL UNKNOWN

Among the things we still do not know are:-

1. How jellyfish venoms kill humans;[6,7]
2. How much of a dose of venom is absorbed by lymphatics and how much by capillaries;
3. The metabolism and excretion of venoms[8];
4. The in vivo action of existing antivenoms;
5. How to provide simple, safe and effective analgesia for first aiders to use.

THE FUTURE

Better care of patients suffering from jellyfish envenomation can only come from better education of medical practitioners in the subject of marine envenomation.

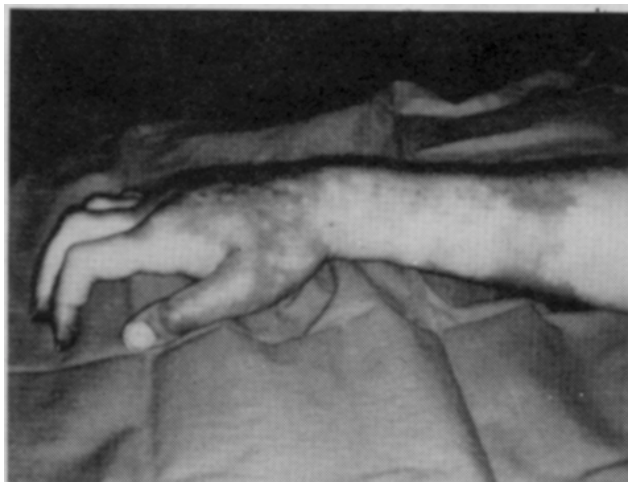

**FIGURE 4**

The near gangrenous arm of a young female stung by either a *Cassiopea* or *Chironex* jellyfish in the waters off the Goa coastline, in India. This resulted in arterial vascular insufficiency following envenomation on the skin of the upper arm.

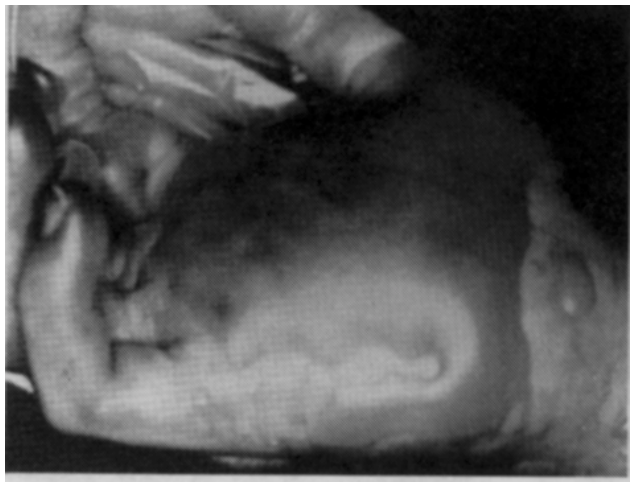

**FIGURE 5**

Severe consequences of the same jellyfish sting shown in Figure 4, 6 days following envenomation; shows blistering and threatened skin death distal to the actual sting site, due to a combination of primary toxic and secondary ischaemic effects. Other jellyfish stings may produce vesicle formation at the site of tentacle contact.

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# ORIGINAL PAPERS

## THE ROLE OF HYPERBARIC OXYGEN IN THE TREATMENT OF THERMAL BURN INJURIES: A BRIEF REVIEW OF THE LITERATURE AND THE RESULTS OF A PILOT STUDY.

Des Gorman and Ian Leitch

### Introduction

Thermal burn injuries are common, and have a substantial morbidity and mortality. Both the treatment in specialised Burns Units, and the rehabilitation of the patient back into the community are expensive[1]. Despite this background, the evaluation of different treatments for burnt patients has been poor. Often studies have inadequate control data and there are difficulties in accurately assessing burn wound depth[2].

Hyperbaric oxygen (HBO) therapy administered systematically may be an effective adjuvant to the conventional care of thermal burn wounds, since it can reduce tissue ischaemia, attenuate interstitial fluid oedema and compartment pressure, improve the micro-circulation, and stimulate both revascularisation and re-epitheliasation of hypoxic wounds[3].

Since the original observation of accelerated burn wound healing in rabbits treated with HBO was reported in 1969[4], data have been collected in a variety of other animal-models to demonstrate at least three ways in which HBO acts directly to promote healing of thermal burn wounds.

The first is a reduction in the eventual depth of the burn wounds (ie. the progression of partial-thickness burns to full thickness is retarded)[5]. This reduction is associated with less extravasation of fluid[6,7], an increase in the ATP concentrations in the burn wounds (even when HBO administration is delayed)[8], and a reduction in overall animal mortality[6]. The second direct action is an increased healing rate of burn wounds in animals treated with HBO[4,5], and the third is an anti-septic effect[4,6]. This anti-sepsis is mediated probably both by enhanced host responses and by direct anti-bacterial action[3].

The beneficial effects of HBO may be enhanced by the concurrent administration of antioxidants, but their use is controversial. For example, while a free oxygen-radical scavenger enhanced the protective effect of HBO on a rabbit lung smoke inhalation injury[9], similar benefit could not be demonstrated in ischaemic skin flaps in rats[10]; and elevated oxygen tensions have been shown to actually antagonise, not potentiate, lipid peroxidation in-vitro[11].

In addition to these direct effects on burn wounds, HBO has also been shown to improve outcome in animals who have inhaled cooled smoke[9], by reducing the fluid extravasation into the lung interstitium. Lung injury from smoke inhalation is common after thermal burn injuries, and is a significant cause of mortality[12]. Carbon monoxide (CO) intoxication has been claimed to be the commonest cause of death of victims dying at the scene of a fire[13,] and HBO has been shown to be the definitive treatment of CO intoxication in a controlled prospective study[14].

In contrast to these controlled animal studies, reports of HBO use in humans with thermal burns are, with perhaps a single exception, poorly controlled. Also, these human studies have used unreliable methods of assessing burn-wound depth[2]. These retrospectively, semi, or uncontrolled studies have reported that HBO: reduces the mortality in severely burnt patients[15]; reduces either the number of areas, or the surface area requiring grafting[1,15,16]; reduces fluid requirements[13,15,17]; reduces hospital-stay time and overall treatment costs[1,13,16]; reduces burn wound sepsis[17]; and increases skin graft survival in patients who have had burn wounds grafted[13,15]. However there has been only one prospective controlled, but not randomised, study of 875 patients with thermal burns, which showed HBO to significantly reduce the mortality of severely burnt patients[18]. There are no human data and only a single report of an inhalational injury in rabbits being improved by the administration of normobaric oxygen (NBO)[19].

There are no reports of adverse effects on burns with systemic HBO, and a solitary report of topical HBO increasing scar thickness[20].