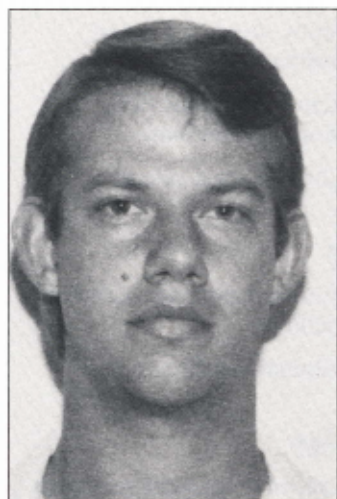


The role of the Medical Practitioners in the prevention & treatment of scuba diving related accidents — FJ Cronjé



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Curriculum vitae

Frans J Cronjé was born in London on 16 May 1966. He matriculated with six distinctions in 1983, at the Afrikaans Hoër Seunskool, where he also was vice-head boy. After completing basic training in the SAMS, he was selected for the officer's course and received his commission in 1984. In 1986 he started his medical studies at UP and has pursued his interest in diving since his third year. At present he is a qualified NAUI Dive Master, with courses in advanced diving and rescue to his credit. He gives lectures on diving medicine in his spare time.

Summary

Scuba diving is becoming increasingly popular - more than 20 000 certified divers in RSA today. Physicians need better information, not only to cope with the accidents but also to prevent them. This article includes a list of physical prerequisites, considerations and absolute contraindications for scuba diving, pointers on the pre-dive medical and follow-up examinations of the diver. A helpful, practical approach to the management of diving related injuries is also given.

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Introduction

There are no specific regulations governing the medical clearance of sport scuba divers and although commercial and other diving schools require a clearance certificate from a general practitioner for candidates attending their courses, these are more to protect these institutions from litigation, than to protect the future diver from injury.

I believe it to be essential for the general practitioner to function in two capacities where diving is concerned:

- * He should be fully aware of the specific physical prerequisites, considerations and absolute contraindications for scuba diving.

He should further be able to explain the importance of disqualifying illnesses to the patient, who might be tempted to seek his medical clearance from a less informed colleague.

- * He should be able to supply effective emergency first aid in diving related accidents. Although he cannot be expected to administer specialised treatment like recompression, he should be familiar with a few effective and elementary forms of treatment for the various common or urgent diving maladies.

In this article I have included a list of the physical prerequisites, considerations and absolute contraindications for scuba diving, pointers on the pre-dive medical and follow-up examination of sport scuba divers and a practical approach to the management of diving related injuries.

The physical prerequisites & contraindications for scuba diving

The subaquatic environment is governed by various natural laws concerning pressures, volumes, buoyancy etc. These all effect the diver and place specific physical demands that need to be met. Further, minor medical incidents easily treated on terra firma, could easily prove fatal in 12 metres of water.

In spite of the innumerable medical conditions that need consideration, the most can easily be weighed up against the two golden rules for scuba diving:

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* *The ability to withstand and equalise increasing and decreasing air pressures and volumes.*^{5,11} In other words, conditions predisposing to air trapping or blocking of air passages disqualify a person from scuba diving

* *The absence of any conditions jeopardising consciousness or predisposing to acute incapacitating illness under water (eg epilepsy or diabetes)*¹⁶

Here is a list of the most important physical prerequisites and contraindications for scuba diving:

*Ear Nose & Throat**Ear:*

- Intact tympanic membrane
- Ability to inflate middle ear by gentle Valsalva manoeuvre
- CI: * Perforation
 - * Chronic otitis media
 - * Mastoid operation
 - * Inability to inflate middle ear by Valsalva manoeuvre

Nose & Sinuses

- Patent nasal airway and sinus openings
- Absence of chronic nasal or sinus symptoms
- CI: * Chronic catarrh of upper airways or recurrent sinusitis

Oral, Dental & Maxillofacial:

- Ability to hold scuba mouthpiece in place, with or without special devices¹⁰
- Good oral hygiene (to prevent tooth barotrauma)

Eyes

- Visual acuity more than 6/18.¹⁴ If less, corrective lenses are indicated, preferably built in to the mask. Unfortunately positive dioptr, built-in lenses are scarce.

Contraindications:

- 1) Recent eye surgery
- 2) Radial Keratotomy (permanently)

Lungs & Chest

- Absence of acute or chronic obstructive airway disease that could lead to air trapping and increase the risk of burst lungs during ascent.
- CI: * Chronic lung disease (COAD; TB etc)
 - * Bronchial asthma
 - * Pneumothorax (spontaneous/traumatic)

Cardiovascular

- Cardiac fitness appropriate for diving (see miscellaneous)
- CI: * Heart disease (ischaemic, arrhythmias, failure)
 - * Hypertension, uncontrolled or treated with centrally working medication eg methyl dopa or with signs of target organ damage (eyes, brain, kidneys, heart)

Gastrointestinal, Abdominal & Renal

- No acute or chronic illnesses that could be exacerbated by diving (eg peptic ulcer)
- CI: * Abdominal hernia

- * Peptic ulcer (active) or esophagitis
- * Active infections (TB; cholera; amoebiasis)
- * Chronic renal calculi

Endocrine

- CI: * Insulin dependant diabetes mellitus
- * Adrenal insufficiency

Dermatology

- CI: * Excessive sunlight sensitivity
- * Allergy to neoprene, silicon etc.

Musculoskeletal

- No conditions predisposing to fractures eg osteoporosis, osteogenesis imperfecta, etc.
- CI: * Unhealed fractures
 - * Gross deformity making movement underwater ineffective (See footnote on handicapped divers¹)

Neurologic

- Unimpaired consciousness & concentration
- Sufficient co-ordination to execute diving techniques
- CI: * Epilepsy or conditions that make seizures a more than average risk eg intracranial surgery, sepsis or injury

¹Certain institutions specialise in the training of handicapped divers, eg paraplegics.¹⁰ I am not aware of any in South Africa, however.

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Psychiatric

- Appropriate motivation for diving combined with responsibility and level headedness
- CI: * Depression, psychosis, alcohol or drug addiction
 - * Fears incompatible with diving eg agoraphobia, thalassophobia or claustrophobia

Miscellaneous

- Mandatory age limit of 14 years
- *Pregnancy:* Diving contraindicated due to its danger to the foetus^{1,2,6,13}
- *Medication:*
 - * No drugs causing drowsiness
 - * No dependence on medication to be able to dive (eg decongestants)
- *Level of fitness:*

Some diving schools require a fitness test consisting of:

- * 200m free style swim in 8 minutes
- * Treading water for 1 minute (no hands)
- * Retrieving 6 objects in 2 metres of water
- * 25 metre underwater swim

One should judge whether the patient would be able to complete such a test, let alone pass it!

- *Smoking:* Although numerous diving instructors set a very bad example by smoking it should be strongly discouraged. Smoking increases the risk of lung barotrauma considerably. The bottom line recommendation is *not to smoke within 2 hours before a dive.*⁶

Examination of sport scuba divers

Diving schools sometimes issue candidates requiring medical clearance with an appropriate form to be undersigned by the doctor. This may or may not contain a specific checklist to work through. Often the general practitioner may be at a loss as to what should be examined or how to approach this. Guidelines for examination and a checklist that may be useful are given in Form I at the end of this article.

Personal History

This is mostly filled in by the diver himself, after which the examiner may read through it and ask further complementary questions if deemed necessary. This ensures that all relevant aspects are covered while being very cost effective.

Physical examination

Examination includes the following three elements:

- * General systemic examination
- * Excluding disqualifying conditions
- * Special investigations

General Systemic Examination:

Although all systems should be evaluated, special attention should be given to:

- Heart & Lungs
- ENT
- Abdomen (hernias)
- Consciousness, co-ordination & balance
- Psychiatric assessment

Excluding disqualifying conditions

The following tests & examinations are required:

- Equalising middle ear pressure under otoscopic surveillance (the tympanic membrane should move)
- BP (if > 150/100 mm Hg, requires further examination)
- Urine (No albumin, glucose or blood)
- Pregnancy test negative (when in doubt)
- FEV₁ > 75% of Vital Capacity. If < 80% repeat after bronchodilator. Flow meter can be used as a sifting test.

A modest estimate of 20 000 certified scuba divers in South Africa today

Special Investigations:

- * *Compulsory:*
 - Chest X-ray
 - ECG (all persons over 40 years)^{1,2,6,13}
- * *Optional:*
 - Lung Function Tests
 - Sinus X-ray
 - EEG
 - Echo-/phonocardiography or cardiac catheterization⁴ (to exclude a patent foramen ovale, which increases the risk of arterial air embolism)

After the initial clearance for a diving course, the prerogative now lies with

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the individual to visit the doctor again for follow up checks. There are no hard and fast rules about these, but the suggestion of the British Sub Aqua Club (a highly respected organisation) seems to be the minimum:

- * Five yearly up to the age of 30
- * Three yearly up to the age of 50
- * Annually thereafter

After a dive, all divers are dehydrated to some extent

This sequence should be suggested to the future diver on his very first visit, or it may very well be his last. Additional appointments should be made if any problems arise.

Emergencies

Scuba diving has become an exceedingly popular sport in South Africa. Currently there is a modest estimate of 20 000 certified scuba divers. 100 000 dives were logged in 1990. Scuba Diving is also not limited to coastal areas. Active scuba diving is undertaken in the Witwatersrand and Pretoria-area, in places like the Roodeplaat dam, Bass lake and Wondergat. Proportionally the likelihood of an accident is on the increase and the medical practitioner should be able to cope with this.

Diving emergencies usually fall into one of four categories:

- * Bubble trouble & barotrauma
- * Marine animal injury
- * Thermal stress
- * Diverse trauma and near drowning

The first two are directly related to scuba diving and will be discussed:

The Treatment of Bubble Trouble

Bubble trouble can be divided into:

Lung Over Pressure Injuries (LOPI)

- Arterial Gas Embolism
- Pneumothorax
- Mediastinal/Subcutaneous Emphysema

Decompression Sickness (DS)

- Type 1 (non-neurologic)
- Type 2 (neurologic)

Of all these, arterial gas embolism and decompression sickness are almost synonymous with scuba diving. The emergency treatment is also essentially the same and consists of 4 components:³

- * Diver Distress Position (DDP) & 100% Oxygen
- * Medication
- * Fluids
- Urgent Transport to a Recompression Facility

Diver distress position & 100% oxygen

The DDP (See Fig 1) serves 2 purposes:

- It prevents bubbles from entering the cerebral circulation by lowering the head
- And if a foramen ovale exists (incidence 25%) the DDP prevents bubbles from being shunted to the systemic circulation. Instead they are moved to the lungs and eliminated in the "pulmonary bubble trap" or capillary network.

Bubbles block blood vessels, causing hypoxia and pain. Oxygen delivered by demand valve (or mask) is the first definitive step in relieving the effect of the bubbles by:

- Saturating the tissues and so effectively bypassing the blocked blood vessels.
- Creating a high diffusion gradient by which the nitrogen bubbles are more speedily eliminated.

Medication

The following should be administered intra venously or orally

Fig 1



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in all cases of embolism or DS:³

- Soluble (Dispirin) or injectable (Delgesic) *Aspirin 600mg stat.* This is used as a mild analgesic and for its anti-coagulative properties, to prevent the bubbles from triggering the coagulation cascade.
- *Methyl Prednisolone (Medrol) 32mg stat.* This is used to combat shock & reduce perivascular and pulmonary oedema.
- *Vitamin C (Scorbex) 500mg stat.* Used for its cell stabilising (anti-oxidative properties).
- *Diazepam (Valium) 10mg stat.* Apart from being used as a sedative, it protects the brain from the high partial pressures of oxygen administered during recompression therapy and prevents convulsions.

Fluids

In all but the most negligible cases of DS, and even then one should remember that type 1 often progresses into type 2 DS, *Dextran 40 plus 40ml 50% Dextrose*¹⁴ should be allowed to run in over 60 minutes. After a dive all divers are dehydrated to some extent which aggravates DS. Dextran acts as both a volume expander and an anti-coagulant. Further, if conscious, the diver should be prompted to drink *250ml of Isotonic Fluids (Game)* every 45 minutes.

Transport to a recompression facility

This should take precedence over everything else. The sooner recompression is begun, the more likely the patient will recover completely. Recompression chambers should be informed of the casualty by telephone.

The recent creation of "DivEvac" in August 1990 has changed the face of diving emergencies as it has placed specialist help and information just a phone call away. The number to phone is (011) 403-7080 and is available 24 hours a day. DivEvac also provides emergency response

Since August 1990, specialist help for diving emergencies available by telephone (DivEvac) (011) 403-7080

and other services, which are available to members. For more information phone: (011) 403-7090.

Pneumothoraces and other forms of barotrauma like sinus squeeze, sub-conjunctival haemorrhage and tympanic membrane rupture fall outside the scope of this article and I refer you to some of the references.^{1,2,3,13&15}

The Treatment of Marine Animal Injury

Hazardous marine life can be divided into 5 groups:

- * SNAPPERS: Sharks, moray eels, game fish, killer whales
- * STICKERS: Stone-, Scorpion-, fire fish, sea catfish, stingrays etc.
- * SCRAPERS: Fire coral, certain sea weeds, etc.
- * STINGERS: Blue bottles, jelly fish etc.
- * SHOCKERS: Electric eels & rays

This division is convenient as the treatment of wounds inflicted by members of each group is similar.

SNAPPERS^{12,14,17}

Remember:

- Shock is the thing that kills
- Secondary infection is the rule

In her book "Treatment of Shark Attack" Beulah Davis reports the following: "*Analysis of fatal cases suggests that uncontrolled haemorrhage and premature movement of a hypovolaemic victim contribute to the reported high mortality rates after major shark attacks. If adequate hemostasis is assured, there is nothing to be gained by moving the victim of an attack before the circulation has been stabilised by the infusion of 500 -1000 ml of 4% Albumin/Ringers Lactate solution (as supplied in the modified Feinberg Shark Attack Kit available on all life guarded beaches). Most victims are young people with good compensation for hypovolaemia and the delay for 30-60 minutes, generally recommended, will make the transport to hospital less hazardous. In the interim limbs are splinted and pain relieved by carefully titrated intra venous dose of morphine hydrochloride. The decision to move the patient should be made by the doctor or trained lifeguard, who must not be influenced by the opinion of untrained bystanders and ambulance workers.*"

Hospital care involves:

- * Further treatment for shock.
- * Debridement & dressing of wounds.
- * Antibiotics (Cephalosporin & Gentamycin; Penicillin x 10 days; Tetanus toxoid)
- * Primary or secondary suturing (depending on the nature of the wounds)

To a large extent this protocol also serves for the wounds inflicted by other snappers.

STICKERS, STINGERS & SCRAPERS^{2,6,8,9,12,13,14}

Remember:

- * Marine venoms are proteins
- * Cardio Pulmonary Resuscitation (CPR) saves lives

The protein structure of marine venoms make them hyperallergenic, extremely toxic and denaturable by heat, acids, alkali's & enzymes. Bearing this in mind, an anti-venom kit should contain:

- * Anti-histamines & topical cortisone cream for allergic reactions
- * Vinegar & ammonia to neutralise certain venoms
- * Alcohol to immobilise & fix tentacles
- * Commercial meat tenderizer, an extremely effective proteolytic agent
- * Hot water (55-60°C) that destroys all marine venoms

The most effective treatment for STICKERS consists of:

- Immersing the affected limb in hot water for between 30 & 90 minutes or intermittently until permanent relief is achieved. This can be life saving if started quickly (eg stonefish)
- Anti-histamine & antibiotics (Penicillin)
- Resuscitation, reassurance & support
- Always hospitalise (except in very mild cases of sea urchin stings)

Special note on sea urchins:

Those encountered in South Africa are only mildly toxic and the spines,

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which invariably break off after penetrating are best left alone if they don't come out easily. They will dissolve after a while in any case without ill effect.

The most effective treatment for STINGERS is:

- Fixing & immobilising tentacles with alcohol (brandy will do)
- Scraping tentacles off with a blunt knife (in one direction)

Applying liberal amounts of meat tenderiser and rubbing it in, or weak ammonia solution.

- Anti-histamines
- Only serious cases need to be hospitalised

Most accidents occur only because of ignorance, panic or a physical problem

The most effective treatment for SCRAPERS is:

- Meat tenderizer (or vinegar)
- Anti-histamines if a rash develops
- Hospitalisation is very seldom necessary

The shocks inflicted by SHOCKERS are self limiting.

In all of the above hot water will prove effective. However the discomfort thereof will only be tolerated if the injury is worse (eg stickers), but if more conservative treatments fail, never be afraid to use it.

Conclusion

Why is it that a million people in America and over 20 000 South Africans insist on returning again and again to this alien environment, fraught with dangers?

There is nothing that can quite prepare you for the splendour of the sub aquatic environment. No description as vivid as the gardens of the deep. No sensation that can equal the feeling of weightlessness, cool water and the overwhelming savage beauty of the Big Blue.

Accidents mainly occur where divers are ignorant, panic or are *physically* not capable of coping. We as physicians can largely prevent the "incapable" of becoming yet another statistic and if not, at least ensure a favourable outcome.

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