Outline of medical standards for divers

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Hickey DD. Outline of medical standards for divers. Undersea Biomed Res 1984; 11(4):407-432.—Information required for the medical examination of sport, commercial, and military divers is provided. The paper adheres to an outline format and covers the diver’s medical history as well as specific points to look for in the physical and laboratory examination. Numerous disqualifying conditions are listed and they are divided into absolute contraindications and relative contraindications. Physical work capacity standards are also included as well as pressure and oxygen testing. References have been drawn from the international literature, and sources of additional medical information are provided.

- air embolism
- arrhythmia
- barotrauma
- diving
- drowning
- drug interactions
- hypothermia
- immersion
- Naval Medicine
- osteonecrosis

FOREWORD

Several excellent references on diving medicine are available today. Nevertheless, physicians who engage in diver medical examination on an occasional basis will not find answers to all their questions by consulting a single source. Furthermore, inasmuch as diving medical expertise is based on personal experience in the absence of hard fact, physicians who rely on a single reference are often depriving themselves of other, equally valid, points of view. Finally, specific medical information on fitness to dive is often buried in large bodies of text and is inadequately identified in the index. To remedy these problems, this outline pools clinically relevant information in an easily read and readily referenced format. Every effort has been made to rely on the international literature and to minimize any parochial bias. Original contributions have been referenced when known and the author has tried to avoid statements of personal opinion not shared by those more experienced.
The scope of this paper reflects the belief that because the physiological and medical aspects of diving are shared by all divers, differences between standards for sport, military, and commercial divers are those of degree and not of kind. Therefore, information relevant to the medical evaluation of all divers is provided, at the same time emphasizing different standards for recreational and professional divers where appropriate. The reader is cautioned that government and industry provide specific guidelines for the medical clearance of military and commercial divers, and that requirements must be strictly followed where applicable. Physicians performing such examinations have usually received training in diving medicine and must meet various professional requirements before approval is granted to conduct medical examinations for professional divers.

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INTRODUCTION

 Physicians who examine divers must understand the diving environment and the health hazards that it imposes. Ideally, they should be divers, but if not, they should take care to acquaint themselves with practical diving information (1-3) as well as the diving medical literature.

 No government in any country regulates sport diving. Thus, physicians are not in a position to “forbid” a candidate to engage in recreational diving. Rather, their role is to explain medical risks and to advise the candidate accordingly. Physicians should realize that many diving medical caveats are based on anecdote rather than solid evidence, and that the opinions of respected hyperbaric specialists can vary. Therefore, they should strive to make decisions
based on a consensus and on the circumstances of the particular diver. They should also be aware that many candidates will continue to dive with known medical contraindications and will not suffer ill effects. Such persons will be difficult to deal with; the physician’s role can only be to point out the possible medical consequences and the divers’ responsibility to their families, diving partners, and others who may become involved if things go awry.

The situation is somewhat different when screening commercial or military diving candidates. Governments and diving companies often have specific physical standards and brook no exception. In these circumstances, physicians may be obliged to deny a candidate they personally feel should be allowed to dive.

Physicians should be aware that diving operations are often carried out in remote locations. This consideration should be borne in mind when certifying borderline medical cases, especially for sport divers. Sophisticated medical support, including a recompression chamber, may not be readily available, and transportation of injured divers can further jeopardize successful treatment. Exposure to altitude can precipitate or exacerbate decompression sickness, and injured divers should not (generally) be transported in aircraft if the cabin cannot be pressurized to sea level (1 ATA)(4). Indeed, healthy divers should be cautioned against flying within 12 to 48 h after diving, depending on the depth and duration of the preceding dive (4–6).

Ideally, divers should be medically examined yearly (7), with follow-up examinations being no less rigorous than the initial one. Although it can be argued that certain medical conditions can be allowed in an experienced diver that would disqualify a novice, nevertheless the physician is obligated to uncover any pathologic changes that have intervened since the previous examination. Pleas for leniency may then be considered depending on circumstances, but such decisions must be made with a complete data base.

In this review, medical conditions will be categorized as being either “Absolute” or “Relative” contraindications to safe diving. An absolute contraindication is one which most hyperbaric physicians accept as constituting a sufficient risk to the diver that disqualification from diving is mandatory. A relative contraindication is either a condition that does not enjoy a consensus as grounds for disqualification (yet is conceivably a threat to the diver’s safety) or else represents a temporary condition (i.e., otitis media) that will resolve in time or with treatment, after which diving can be resumed.

WHERE TO GO FOR ASSISTANCE AND ADVICE

Questions will undoubtedly arise concerning the disposition of diving candidates with unusual medical conditions or personal/professional circumstances. Expertise is readily available, both in the United States and abroad.

In the United States

Navy Experimental Diving Unit
Panama City, FL 32407
Telephone (904) 234-4351 or 4353 (24 h call)

National Naval Medical Center
Naval Medical Research Institute
Bethesda, MD 20814
Telephone (301) 295-0283

National Diving Accident Network
Box 3823
Duke University Medical Center
Durham, NC 27710
Telephone (919) 684-8111 (24 h call)

Undersea Medical Society, Inc.
9650 Rockville Pike
Bethesda, MD 20814
Telephone (301) 530-9225
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U.S. Air Force School of Aerospace Medicine
Brooks Air Force Base, TX 78235
Telephone (512) 536-3278 (24 h call)

Undersea Medical Society is an international society and maintains an active, worldwide membership of experienced hyperbaric physicians.

Outside the United States

European Undersea Biomedical Society
Secretary, Philip B. James, MB, ChB
Wolfson Institute of Occupational Health,
Level 5
Ninewells Medical School
Dundee, Scotland

South Pacific Underwater Medicine Society
Secretary, Dr. Christopher J. Acott
Rockhampton Base Hospital
Rockhampton 4700, Australia

Barologa (South Africa)
Contact, Dr. Pieter G. Landsberg
1 Geneva Street
Lakefield, Benoni, South Africa

Société Française de Médecin Subaquatique et Hyperbare (France)
Contact, Dr. A. Durocher
Calmette Hospital
Hyperbaric Unit, Intensive Care
Blvd. Prof. Leclercq
59037 Lille, France

Societa Italiana de Medicina Subacquea ed Iperbarica (Italy)
Secretary, Dr. Roberto Rusconi
Direttore Tecnico
Centro Medicine Iperbarica
Via Venezia 7
Zingonia (BG) 24040, Italy

Norwegian Underwater Technology Center
Gravdausveien 255-5034 Ytre Laksevag
Bergen, Norway
Telephone (47) 5-261601

Defence and Civil Institute of Environmental Medicine
1133 Sheppard Avenue West
P.O. Box 2000
Downsview, Ontario, M3M 3B9 Canada
Telephone (416) 635-2000

Japan Marine Science and Technology Center
237 2-15, Natsushima-cho
Yokosuka, Kanagawa Prefecture, Japan
Telephone (0468) 66-3811

North Sea Medical Center
3 Lowestoft Road
Gorleston-on-Sea
Great Yarmouth, Norfolk NR31 6QB,
England
Telephone (0493) 600011 or 61617

This list is by no means exhaustive, and numerous government and commercial concerns employ physicians with expertise in diving medicine. Information can frequently be obtained from Diving Medical Officers serving in the various navies around the world.
MEDICAL HISTORY

A thorough medical history is an important first step in evaluating any diver, and should include the usual format: history of specific complaints; review of systems; inquiry concerning present medications, allergic conditions, drug or alcohol dependency; and social, family, and psychiatric histories. In addition, a diving medical history should be taken. When done properly, the physician can learn much about the diver’s practices and judgment, as well as specific medical conditions that relate to the hyperbaric environment. The following topics should be addressed:

Current diving practice or goals of candidate

- Sport diving
- Commercial diving
- Military diving
- Experimental or research diving
- Hyperbaric medicine as a nurse or chamber attendant
- Caisson worker
- Deep or saturation diving

Diving history of candidate

- Where was the candidate trained?
- How long has he been diving?
- What kind of diving has he undertaken?
- To what depths has he dived?
- How often does he dive?

History of previous diving related medical problems of candidate

- Air Embolism
- Decompression Sickness*
  - Bends (Type I)
  - Neurological (Type II)
- Barotrauma, including pneumothorax
- Vertigo
- Near drowning
- Osteonecrosis
- Nitrogen narcosis
- Oxygen toxicity
- Visual disturbances
- Treatment in a recompression chamber
- Prior medical disqualification

*Recurrent decompression sickness can be more severe and harder to treat in divers who are experiencing sequelae from prior decompression sickness.

Ancillary considerations

Age

Divers over age 36 have an increased bends incidence (5), generally decreased levels of fitness, and an increased risk of osteonecrosis (5).
Dissimulation

The physician should understand that candidates want to dive and may deliberately conceal medical problems. An appropriate medical history form, completed and signed by the diver, may provide some legal protection for the examiner.

Smoking

Smoking is conducive to lung parenchymal disease that promotes air trapping, a potentially lethal problem in divers. As such, it is to be discouraged.

Blood donation

Divers should not dive for at least 48 to 72 h after blood donation (8).

Acute illness

Any acute illness should constitute a temporary contraindication to diving.

Drugs

Recent research has shown that many different classes of drugs can have an unpredictable and/or deleterious impact when used in a hyperbaric environment (9). Any pharmaceutical which can influence the conscious state or the body’s response to stress should be viewed with suspicion. Certain drugs can potentiate nitrogen narcosis, oxygen toxicity, arrhythmias, fatigue, mental clouding, motor impairment, and susceptibility to hypothermia. These drugs include:

- Sedatives and tranquilizers
- Antidepressants
- Antihistamines and decongestants
- Hypoglycemic agents
- Adrenergic blocking agents
- Steroids
- Anticonvulsants
- Alcohol
- Hallucinogens

- Thyroid drugs
- Antihypertensives
- Coronary vasodilators
- Narcotics
- Antituberculosis agents
- Chemotherapeutic agents
- Antipsychotics
- CNS stimulants and anorexiant
- Antigout agents

*Dimenhydrinate (Dramamine) has been used safely at depths to 55 m (4)

A limited amount of practical experience with 57 different pharmacologic preparations at depth has been reported [Appendix 17 in (6)]. The majority of drugs displayed normal therapeutic efficacy. The reference suffers from a failure to use generic drug nomenclature, and the circumstances of diver employment and performance after drug administration are not always clear. Nevertheless, the information provided is both unique and important.
PHYSICAL EXAMINATION

Eyes, ears, nose, and throat

Caveat

The examiner must be sure that the diver can perform pressure equilibration (auto-inflation) successfully. The Valsalva maneuver, swallowing, or jaw movement may facilitate equilibration. A consideration of Boyle’s Law should guide the examiner in anticipating potential problems. In all cases the eustachian tube and sinuses must be patent and the tympanic membranes must be proven intact and mobile by insufflation or auto-inflation.

Absolute contraindications (4, 7, 8, 10–13)

1. Otosclerotic surgery (stapedectomy, prosthesis, and reconstruction of the oval window)
2. Chronic or serous otitis.
4. Inability to clear the middle ear for any anatomical or permanent functional reason.
5. Chronic mastoiditis or mastoid fistula.

Relative contraindications (4–8, 10–16)

1. Allergic rhinitis
2. Pharyngitis
3. Tonsillitis
4. Dental caries
5. Nasal polyps (if they interfere with pressure equilibration)
6. Deviated nasal septum (if it interferes with pressure equilibration).
7. Habitual nose bleeds (12)
8. Sinusitis
9. Acute otitis externa
10. Acute otitis media
11. Perforated tympanic membrane. This condition would be acceptable for dry (chamber) personnel.
12. Any upper respiratory infection.
13. Recovery from ear barotrauma (squeeze): 8 h to 4 wk lay-off is recommended, depending on severity (5).
14. Cerumen that obscures the tympanic membrane should be removed by gentle syringing. If the membrane is not obscured, one authority recommends leaving cerumen in place since it is bacteriostatic (4).
15. There are several types of tympanoplasty, the simplest of which is repair of the tympanic membrane (14). Certain types involve repair of the ossicular chain. Any such repair stopping short of replacing the stapes might be allowed provided full healing and the blessing of the otolaryngologist who performed the surgery. If the patient cannot clear the middle ear, rupture of the round or oval window (perilymph fistula) is a real hazard. The use of an ossicle prosthesis predisposes to spontaneous or provoked oval window rupture (4).
16. Hearing standards (U.S. Navy, 15). A maximum threshold level in either ear by audiogram in excess of the following limits is disqualifying for military diving. Most commercial standards are similar (7, 8).
MEDICAL STANDARDS FOR DIVERS

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>500</th>
<th>1000</th>
<th>2000</th>
<th>3000</th>
<th>4000</th>
<th>8000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum level in dB in either ear</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>45</td>
<td>60</td>
<td>+</td>
</tr>
</tbody>
</table>

The average level at 500, 1000, and 2000 Hz cannot be greater than 30 dB, with no level greater than 35 dB at any one frequency. The threshold at 8000 Hz is recorded for baseline information only.

17. Audiometry is recommended yearly for commercial and military divers (4). Deafness is probably acceptable for sport divers (who should not dive alone), provided that there is no vestibular impairment. Loss of cochlear function may be associated with loss of vestibular function, especially under poor visual conditions (4). A more conservative hearing standard was also recommended: threshold levels of 20 dB in each ear at frequencies between 500 to 8000 Hz using an audiometer calibrated to ISO standards (4).

18. Edentulous divers are acceptable if the diver can securely hold a mouthpiece. Such individuals should not dive wearing dentures because of the risk of respiratory obstruction should the dentures become dislodged (6, 7).

19. Any mandibular malformation that could impair ability to securely retain a mouthpiece should disqualify the candidate (7).

20. Speech disorders are not acceptable for commercial or military divers where communication is primary and where even normal speech can be compromised in a helium environment (7, 8). Some speech impairment is probably acceptable for sport divers.

21. Proposed NIOSH Standards for vision (10) are:
   - 6/9 in at least one eye corrected (U.S. equivalent = 20/30).
   - Ability to read simple printed instructions at near vision with corrective lenses.
   - Color vision is not important.
   - Fields of vision must be within normal limits.
   - Pupils must be reactive to light and accommodation.
   - Normal retinal exam.

22. U.S. Navy Visual Standards (15) are:
   - Vision must be correctable to 6/6 (U.S. equivalent = 20/20).
   - The candidate cannot be color blind.

23. Minimum acceptable British Commercial Standards (7) are:
   - Uncorrected near: R J16 (N24), L J16 (N24), both eyes J15 (N18).
   - Visual fields should be normal on simple testing.
   - Fundi should be normal.
   - Color vision should be tested at initial examination and candidates should be informed of any abnormalities. The results should also be recorded on the certificate of medical fitness to dive in the diver's log book.

24. Corrective lenses are acceptable for sport divers if ground in the faceplate or if soft or fenestrated contact lenses are worn. Hard contact lenses can cause corneal edema (16).

Cardiovascular system

Stress of diving

The aquatic environment can impose severe stress on an individual's cardiovascular system, and physicians must appreciate the nature and extent of the physiologic responses involved in diving if they are to make rational decisions concerning a candidate's fitness to dive.
1. **Exertion.** Oxygen consumption for fit, young Navy personnel swimming at 1.2 knots is from 2.5–3.0 l/min [Lanphier in (17)]. This falls within the range of "maximal" work.

2. **Immersion (head-out).** A 32%–62% increase in cardiac output has been reported in subjects performing head-out immersion in thermoneutral water (18–20).

3. **Thermal stress.** Ocean water is generally hypothermic (less than 34°C) and as such can represent a hazard to the diver. Cardiovascular changes can be precipitated by cold water (5°C–25°C) immersion. These changes can occur at body core temperatures between 37°C and 34°C, the so-called "excitation phase" of cooling (4, 5).

   Both increased and decreased heart rates have been reported as a result of immersion in cold water (4, 5, 21–23). This appears to be the result of multiple independent variables yet it is safe to say that most recreational diving done in cold (5°C) water evokes a considerable increase in heart rate (23) as well as a profound peripheral vasoconstriction (5), increased oxygen consumption for a given workload (22, 23), increased cardiac stroke volume (22), and an increased systolic and diastolic pressure (5, 21). A 300% increase of endogenous norepinephrine has been reported with whole body immersion in 10°C water (24). Many cold water "drownings" of middle-aged males may be due to premature ventricular contractions or other cardiac arrhythmias that progress to arrest (21, 23).

Hyperventilation can be severe and gasping, and can predispose to aspiration and drowning. Furthermore, hypocapnia induced by hyperventilation has been associated with ventricular fibrillation (5).

A decrement in diver performance due to the distraction effect of cold water has been reported [cf. P. Webb in (5)].

**Breath-hold diving**

This form of diving is engaged in by numerous sport divers and can be unexpectedly imposed on any compressed gas diver should his gas supply fail. Well-known sequelae of breath-hold diving include hypoxia and arrhythmias, and although these stresses are usually well tolerated in healthy subjects, they may prove fatal to older individuals with coronary artery disease (cf. 25, 26).

- **Hypoxia.** Several mechanisms for hypoxia associated with breath-hold diving have been proposed (5, 11, 26, 27) and include hyperventilation before diving (which retards the hypercapnic stimulus to breathe but does not increase the oxygen content of blood) and hypoxia of ascent (due to the falling partial pressure of oxygen as pressure decreases in accordance with Boyle's Law).

- **Arrhythmias.** Numerous arrhythmias have been reported in breath-hold divers, but are usually self-limiting in healthy individuals (cf. 25):

  - sinus bradycardia
  - P wave changes
  - A-V block
  - sinus arrest followed by nodal escape or ventricular escape
  - wandering pacemaker
  - premature ventricular beats
  - premature supraventricular beats
  - tented T waves
  - inverted T waves
MEDICAL STANDARDS FOR DIVERS

- **Panic.** Any in-water emergency carries the potential for panic which imposes even greater stress on the cardiovascular system.

**Workup**

The essential elements of the workup include a careful cardiovascular history and physical examination:

1. **ECG examination.** All commercial divers should have a resting standard 12 lead ECG at the initial examination and be rechecked annually after the age of 35. Postexercise or stress ECGs are done at the discretion of the examining doctor (7, 8).
   - Some authorities recommend only a baseline ECG for sport and professional diving candidates, and suggest subsequent ECG examinations only if cardiac symptomatology develops (10, 11, 13). Another viewpoint (pertaining to sport divers) is that neither resting nor stress ECGs should be done on asymptomatic individuals because there is an unacceptable incidence of both false negative and false positive examinations (28).
   - Some authorities recommend a stress ECG for all diving candidates over the age of 35 (4, 29).
   - A cold pressor test may be performed. This consists of monitoring ECG and blood pressure while the candidate immerses a hand in cold water (4, 29).

2. **Blood Pressure.** Resting blood pressure should not exceed 140/90 mmHg (7, 12).
   - The Norwegian standard is more liberal (8): 160/90 mmHg sitting.
   - For sport divers the blood pressure should be within the normal range for the diver’s age (4, 29). [For comparison, the U.S. Federal Aviation Administration maximum allowable resting blood pressure for second and third class pilots over the age of 50 is 170/100 mmHg (30).]

**Absolute Contraindications (4, 10, 29, 31, 32)**

1. Myocardial infarction within the past year.
2. Angina or other evidence of coronary artery disease.
3. Congestive heart failure.
4. Potential right to left shunts, i.e., septal defects, patent ductus arteriosus, and pulmonary A-V fistulas. Shunts pose a real danger in that venous bubbles could pass through and become arterial emboli (31).
5. Significant valvular disease.
6. Coarctation of the aorta.
7. Electronic pacemakers may or may not function properly at depth and fixed-rate pacemakers do not provide adequate cardiac output during exercise. New variable rate pacemakers look promising, but are untested in divers (32).
8. Prosthetic valves.
9. Intraventricular conduction defects.
10. Wolff-Parkinson-White syndrome.
11. Significant cardiac arrhythmias, except occasional premature ventricular contractions.
13. Peripheral vascular disease.
14. Use of anticoagulant drugs.
15. Cardiac surgery for coronary artery disease (Author’s opinion). Sport divers may be able to resume diving if they meet certain conditions [post myocardial infarction (below)], and with due regard to the diving implications of thoracotomy.


17. Exceptions. The following conditions will generally not disqualify divers:
- Isolated right bundle branch block in an asymptomatic patient with no evidence of heart disease (4, 10, 29).
- First degree heart block with normal exercise stress test and no evidence of underlying heart disease (4, 29).
- Postmyocardial infarction (sport divers only) if:
  - One year has elapsed without experiencing angina or arrhythmias at maximal exercise (4);
  - Normal exercise stress test (4);
  - Examination every 6 months by a cardiologist.

The diver must thoroughly understand the risks to himself (and to his diving buddies should he suffer a myocardial infarction while diving), and he should avoid strenuous diving and cold water exposure.

- Supraventricular tachycardia in sport divers if (29):
  - Otherwise young, healthy individuals;
  - Normal exercise stress test;
  - Associated cause has been ruled out (hyperthyroidism, hypertension, mitral valve disease, pulmonary embolism, excess alcohol, nicotine or caffeine intake);
  - The tachycardia is well controlled with “small amounts” of digitalis.
- Bradycardia in a fit individual if there is a normal response to exercise (29).
- Occasionally, individuals with left bundle branch block may be cleared for diving if (4, 29):
  - No history or clinical findings suggestive of heart disease are present;
  - Normal chest x-ray;
  - The physician may want to perform a cardiac ultrasound study and/or an exercise stress test.
- Isolated mitral valve prolapse (the click-murmur syndrome), found commonly in women, is not a contraindication to diving (5, 29). Such patients are apt to be taking beta-blockers, however, and the physician should evaluate the patient’s response to exercise.

Relative contraindication

1. Hypertension. especially if there is end-organ damage (i.e., to kidney, retina, or heart) (4). The uncontrolled hypertensive may respond to exercise with very high systolic and diastolic pressures and runs the risk of early exhaustion and heart failure (32).

2. Antihypertensive drugs. These drugs can have an unpredictable effect on the circulatory response to stress or on heart rate and blood pressure during exercise. Patients taking large doses of antihypertensives can have reduced exercise tolerance, poor thermal balance, and occasionally orthostatic hypotension (32). Some authorities will allow “mild” diuretics for blood pressure control in sport divers (11, 13). Sport diving might also be allowed for patients
on small doses of beta-blockers, provided they have demonstrated good exercise tolerance and blood pressure control (32).

3. *Severe varicose veins* are not a cause for rejection if they are treated (7).

**Respiratory System**

**Caveat**

Pathology in the respiratory system is the major cause of diver disqualification. Any lesions that predispose to air trapping can be lethal. Boyle’s Law states that gas volume is inversely related to pressure (temperature being equal). This phenomenon can be responsible for the development of serious over-pressure in susceptible pulmonary structures, provided that gas in the pulmonary tree is not at all times free to equilibrate to ambient pressure. A typical hazard is breath-holding during ascent with scuba gear.

**Workup**

1. A thorough history and physical exam is mandatory.

2. *Annual postero-anterior chest x-ray in full inspiration* (7, 8, 12). Some authorities recommend both inspiratory and expiratory postero-anterior chest films (4, 10, 33), arguing that the expiratory film is more apt to detect air trapping lesions.

3. *Annual pulmonary function tests.* NOTE: Pulmonary function tests may not detect air-trapping disease.
   - Proposed NIOSH Standard (10). To disqualify:
     - Less than 70%–75% predicted VC (from standard tables).
     - Less than 70%–75% of predicted FEV1.
     - Less than 70%–75% of predicted MVV.
   - British and Norwegian Standards (7, 8). To disqualify:
     - FVC less than 50 ml/kg of body weight (8) or FVC less than 3.5 liter (7).
     - FEV1/FVC less than 75% at the initial test (7, 8).
     - FEV1/FVC less than 70% at subsequent tests (7, 8).
     - PEF (peak expiratory flow) less than 500 l/min (8).

4. *History of exercise-induced asthma.* In this case, pulmonary function tests should be done while the candidate exercises at 900 KPM/min (150 W) (4) while breathing cold, dry air. If possible. The examiner should listen to the patient’s lungs during exercise.

   Since the adoption of pulmonary standards for divers in Australia, there has been a dramatic decrease in the incidence of pulmonary barotrauma (4).

**Absolute contraindications** (4, 5, 7, 8, 10, 31, 32, 34)

1. Pulmonary blebs, cystic or cavitary lesions.
2. History of spontaneous pneumothorax. There is a high risk of recurrence (33% over 5 yr) (4, 7, 8, 10). Some thoracic surgeons have argued that bilateral pleural stripping should provide
protection for divers who have experienced spontaneous pneumothoraces (32). This appears
to be a drastic prophylactic measure, and it is unknown whether underlying lung pathology in
these patients may then predispose to air embolism (Author’s conjecture).

3. Active asthma (see Asthma and Bronchodilators, below), by which is meant any one of
these conditions:
- Attacks within the past 2 yr.
- Medication is required to prevent or treat episodes of dyspnea.
- Effort-induced asthma.
- Cold-induced asthma.

NOTE: Childhood asthma with no recurrence is not necessarily disqualifying.

4. Emphysema.
5. Chronic obstructive pulmonary disease.
6. Pulmonary thromboembolism.
7. Recurrent thrombophlebitis.
8. Pneumoconiosis.*
9. Silicosis.*
10. Pulmonary fibrosis.*

*These lesions promote decreased compliance and an increased chance of pulmonary baro-
trauma [Colebatch in (5)].
Broncholiths and hypertrophied lymph nodes could predispose to embolism [Nemiroff and
Dircks in (34)].
14. Patients with sarcoidosis can exhibit oxygen diffusion abnormalities secondary to inter-
stitial infiltrates. Any such patients should be barred from diving because they can experience
hypoxia during exercise (32).

Relative contraindications (4, 7, 8, 10, 11, 32, 35)

1. Thoracotomy or traumatic pneumothorax is a controversial issue (7, 8, 10, 11, 32). Some
argue that the risk of undetectable local air trapping by scarring and adhesive bands is too
great after thoracotomy. Others contend that concomitant pleural scarring should be protective,
and that an experienced diver can be requalified provided he has a normal pulmonary function
test and chest x-ray and has tolerated a chamber pressure test (11). Bove has personal expe-
rience with numerous divers who have experienced chest surgery or traumatic pneumothorax
and have subsequently dived without sequelae. The physician must ensure that the lungs are
reinflated and that the diver has normal chest dynamics. Further, an inquiry into the reason
for chest surgery might uncover pathology that could itself be disqualifying (32).
2. Pneumonia.
3. Bronchiolitis or bronchitis.
4. Mediastinal emphysema.
5. History of pulmonary overpressure accident (pulmonary barotrauma). Some authorities
feel that any risk of recurrence is unacceptable (8, 10, 11). However, the British Diving Medical
Advisory Committee disagrees (35): “After an incident of decompression barotrauma with or
without gas embolism, the diver may be allowed to return to diving within a period of not less
than 3 months, but only after assessment of an ‘Approved Doctor’.”
6. Asthma and bronchodilators (4). Some physicians recommend bronchodilators for asthmatic divers prior to diving. This is a dangerous practice!
   - Asthmatics are far more susceptible to pulmonary barotrauma than are others.
   - Bronchodilators may relieve some, but not all, airway obstruction.
   - An inhaler helps the diver descend, but may not have enough effect at the end of the dive (during ascent).
   - Bronchodilators are known to have arrhythmogenic potential.

Gastrointestinal system

Abdominal pain can be confused with Type II decompression sickness. Furthermore, any lesion that could predispose to gas trapping in a viscus must be cause for disqualification. Any lesion that could interfere with a diver’s ability to perform heavy work or undergo prolonged decompression should also constitute cause for disqualification.

Absolute contraindications

1. Chronic gastrointestinal disease such as ulcerative colitis, Crohn’s disease, or chronic hepatitis (7, 8).
2. There is a theoretical risk of arterial emboli from inert gas bubbles in chronic liver disease due to the presence of multiple pulmonary arteriovenous shunts (cf. 31).

Relative contraindications

1. Gastric and duodenal ulceration, unless there is endoscopic evidence of healing and the candidate has been asymptomatic for at least one year (7, 8, 12).
2. Inguinal or abdominal hernia, unless satisfactory surgical repair has taken place (7, 8). One authority recommends a 6-month lay-off after surgery for hernia (12).
3. Cholelithiasis (7, 8, 12). Otherwise healthy candidates with asymptomatic cholelithiasis probably should be allowed to dive (Author’s opinion), since only 2% of these individuals will become symptomatic on an annual basis (36). Candidates with a history of cholecystitis or biliary colic, however, should be discouraged from diving until corrective surgery is undertaken. Such individuals should be symptom-free postoperatively for 6 months before returning to diving (Author’s opinion).
4. Diverticulitis recurs in about one-third of medically treated cases, usually within the first 5 yr. Recurrence after resection is uncommon. The complication rate of asymptomatic diverticulosis in the general population is probably much lower than 15% (36). For these reasons candidates with asymptomatic diverticulosis or surgically treated diverticulitis (if no postoperative complications) can probably be certified to dive. Divers with a recent history of medically treated diverticulitis who are asymptomatic probably should avoid diving that requires prolonged decompression. In no case should a candidate be allowed to dive with abdominal complaints (Author’s opinion).
5. Postabdominal surgery of any kind until complete healing has taken place.
6. Aerophagia (air swallowing). An individual who habitually swallows compressed gas while diving and is then subject to gastric or bowel distention and pain, nausea, or vomiting on ascent should be barred from diving if he cannot learn better breathing technique or postural control during depth changes. Ear clearing by swallowing can predispose to aerophagia, as can steep, head-first descents (37, 38).
Genitourinary system

Relative contraindications

1. Venereal disease or urinary tract infection will disqualify until adequately treated (7, 8). This includes genital herpes.

2. Evidence or history of nephrolithiasis should be cause for thorough investigation and treatment prior to certification (7, 8).

3. Evidence or history of urinary dysfunction or retention must be fully investigated and treated prior to certification (7).

4. Any abnormality detected on chemical or microscopic examination of the urine should be thoroughly investigated prior to certification (7, 8). Albuminuria may be innocent but acceptance should only be considered after 24-h protein excretion studies (7). Chronic pyelonephritis or glomerulonephritis with mild abnormalities of renal function should not be disqualifying for sport divers if the blood urea nitrogen is below 20 (32).

5. Numerous practical and theoretical risks are imposed by pregnancy (4, 5, 8) that would seem to make diving while pregnant ill-advised:
   - Vomiting and morning sickness.
   - Decreased pulmonary function secondary to an enlarging uterus.
   - Decreased tolerance for exertion.
   - Difficulty with the proper fit of equipment.
   - Unknown effect of high oxygen tensions on the human fetus.
   - Air embolism risk. (There are numerous right to left shunts in the fetus that theoretically could predispose to arterial air embolism should bubbles develop in fetal venous blood. Furthermore, the effect of extravascular (maternal) bubbles on the fetus is unknown.)
   - Increased risk of osteonecrosis [J. Jones in (39)].

Dermatological system

Skin lesions pose problems for chamber or habitat divers who live in close proximity to one another in a frequently humid environment. The problem is compounded if divers share equipment.

Relative contraindications

<table>
<thead>
<tr>
<th>Furuncles and carbuncles</th>
<th>Plantar warts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fungus infections</td>
<td>Scabies</td>
</tr>
<tr>
<td>Impetigo</td>
<td>Pediculosis</td>
</tr>
</tbody>
</table>

Minor manifestations of decompression sickness include pruritis and skin rash. While it is generally held that such lesions (if isolated phenomena) do not require treatment in a recompression chamber, the Diving Medical Advisory Committee recommends a 12-h lay-off from diving (less if the diver is going into deeper saturation) when such manifestations are experienced (35).

Musculoskeletal system

Type I or musculoskeletal decompression sickness presents as limb or joint pain (the “bends”). Therefore, any pre-existing musculoskeletal pathology that could mask or confuse the diagnosis
of decompression sickness is grounds for disqualification. Furthermore, any lesion that could compromise mobility and function in the underwater environment may also be disqualifying, depending on circumstances.

**Workup**

1. A thorough history and physical examination are required, stressing prior pathology, motor strength and symmetry, range of motion of joints, and assessment of low-back symptoms and function.

2. Dysbaric osteonecrosis is a potentially crippling occupational hazard of divers, caisson workers, and hyperbaric chamber personnel. The incidence of this lesion is 2% in U.S. Navy divers, and can be as high as 60%–80% in certain diver populations worldwide (4, 5). Treatment of symptomatic cases is generally unsatisfactory, and medical intervention has been directed at screening divers at risk by using long-bone x-rays or, more recently, bone scintigraphy. An important point of the diver's history is to ascertain whether previous long-bone studies have been performed and to record the dates, findings, and location of the x-ray films (for later comparison if required).

3. Osteonecrosis is associated with disorders of fat metabolism and other diseases. Individual's having the below listed lesions should be barred from diving, chiefly on the basis of the debility occasioned by the primary disease itself, but also to minimize the risk of osteonecrosis (4) (J. Jones in (39), D. Walder in (40)):
   - Gaucher's disease
   - Diabetes mellitus
   - Pancreatitis
   - Cirrhosis
   - Ethanol abuse
   - Chronic phenylbutazone use
   - Sickle cell anemia and other hemoglobinopathies
   - Chronic steroid use
   - Alcaptonuria
   - Syphilis
   - Polyarteritis nodosa
   - Gout and hyperuricemia
   - Hyperlipemia
   - Legg-Calve-Perthes syndrome, Freiberg's disease, Kienbock's disease, and Kohler's disease
   - High radiation exposure
   - Hepatitis
   - Rheumatoid arthritis
   - Arteriosclerosis
   - Gonorrhea

4. The frequency of long bone x-rays (generally for military, research, and commercial divers only) is based on the depth and duration of diving engaged in by the candidate (7):
   - All diving candidates should have long bone x-rays performed at the initial examination, unless they state that they will not be engaged in mixed gas diving, will not dive to depths greater than 30 m, and will not be exposed to pressure for more than 4 h on any single occasion.
   - The frequency of subsequent x-rays will be determined by the diver's experience over the preceding 3 yr.
   - Therapeutic compression for decompression sickness requires annual x-rays for 3 yr. Annual x-rays are also suggested in the case of an asymptomatic osteonecrotic shaft lesion to prove that it has remained stable (5).
   - Except where indicated clinically, long-bone x-rays should not be repeated at intervals less than those specified above. Long-bone x-rays should be read only by radiologists who have experience with dysbaric osteonecrosis. The radiological technique for performing long-bone x-rays on divers is described in numerous publications (4, 5, 8, 12).
<table>
<thead>
<tr>
<th>Maximum Depth Attained, m</th>
<th>Dive Duration On Any Single Occasion, h</th>
<th>Frequency of Long Bone X-rays</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;30</td>
<td>&lt;4</td>
<td>Nil*</td>
</tr>
<tr>
<td>&lt;30</td>
<td>&gt;4</td>
<td>Yearly</td>
</tr>
<tr>
<td>30–50</td>
<td>&lt;4</td>
<td>Every 3 Years*</td>
</tr>
<tr>
<td>30–50</td>
<td>&gt;4</td>
<td>Yearly</td>
</tr>
<tr>
<td>&gt;50</td>
<td></td>
<td>Yearly</td>
</tr>
</tbody>
</table>

*This applies only to divers breathing compressed natural air.

5. Bone scan (scintigraphy) using $^{99m}$Tc appears to be a very sensitive diagnostic test for osteonecrosis, having many advantages over x-ray (41).

**Absolute contraindications**

1. Muscular dystrophy.
2. Neurogenic muscular atrophy, i.e., amyotrophic lateral sclerosis.
3. Myasthenia gravis.
4. Certain osteonecrotic lesions are disqualifying:
   - Juxta-articular lesions of osteonecrosis (4, 5, 12).
   - Any symptomatic lesions of osteonecrosis (5).
   - Progression of any osteonecrotic lesion (5).
5. Nonjuxta-articular, asymptomatic lesions should not be disqualifying, but some authorities suggest that restrictions to diving activity be imposed, especially if the lesion is thought not to have been provoked by nonadherence to established diving tables. In this case, the individual is presumed to be predisposed to dysbaric osteonecrosis (4, 5). Suggested restrictions include:
   - No decompression diving (4).
   - Limited maximum depth (18 m) and slower ascent rates (4).
   - Use of standard air or helium-oxygen tables only (5).
   - No saturation or experimental diving (4, 5).

**Relative contraindications**

1. Post Type I decompression sickness. The U.S. Navy recommends a 7-d lay-off prior to resumption of diving (1).

   The British practice is to impose a 24-h lay-off (less if the diver is going into deeper saturation), provided he experienced full recovery from recompression therapy. If he experienced a recurrence of symptoms or a relapse during or after treatment that required further recompression, a 7-d lay-off is imposed (35).

   Flying in any type of aircraft should not be undertaken for at least 48 h after treatment for decompression sickness (6).

2. Healing fractures. The physician must be satisfied that tissue and vascular repair are complete, so that inert gas uptake and elimination is unimpeded. Some studies have shown an increased incidence of bends at trauma sites (13). Fracture healing times are quite variable and depend on the nature of the injury and the condition of the patient. Assuming no complications (42):
MEDICAL STANDARDS FOR DIVERS

- Long weight-bearing bones: femur 6 to 12 months; tibia 6 months.
- Bones of the upper extremity: 6 to 10 wk.
- The orthopedic surgeon should be made aware of the diver’s occupation, and of the diving physician’s concern over inert gas uptake and elimination at the fracture site. Since the etiology of dysbaric osteonecrosis is poorly understood, a conservative convalescence is probably indicated.


4. History of back injury or back pain. Back pain can adversely affect a diver’s performance and safety on the job, and can also be confused with the symptoms of serious decompression sickness. Furthermore, back complaints are a notorious ploy for malingerers and frequently burden the employer with legal and financial hardship. For these reasons, military and commercial diver candidates with back complaints should be excluded from diving. Sport divers deserve more latitude and can probably dive if reasonable precautions are taken (Author’s opinion).

5. Depending on the extent of the disability, amputees may be capable of sport diving (or limited commercial diving) if common sense prevails, such as the use of appropriate prosthetic devices or the buddy system.

6. It has been recommended that children be restricted to a depth of 9 m (30 fsw) prior to the fusion of their epiphyses. This caveat is based on the theoretical concern that decompression sickness could cause retarded bone growth (4). The time of epiphyseal fusion is variable and depends on the particular bone and the sex of the child. Fusion generally is completed between the 13th and 16th yr in girls, and between the 15th and 18th yr in boys (43).

Endocrine system

Clearly, flagrant disorders of the endocrine system which leave the patient with obvious debility would be grounds for immediate disqualification from diving. Less clear-cut lesions are discussed below.

Absolute contraindications

1. At the present time most authorities recommend that insulin-dependent diabetes is sufficient grounds for disqualification (5, 8, 10–13, 32). They argue that the stress of diving is hard to predict and that the risk of loss of consciousness is too great. Furthermore, small vessel disease could play a role in decompression sickness. While it is appreciated that some insulin-dependent diabetics dive without mishap, it is highly unlikely that military or commercial organizations would be willing to assume liability for their employment.

2. Generally, individuals who require oral hypoglycemic agents for control of diabetes mellitus are disqualified. Some authorities allow sport diving if the individual is well-controlled by diet alone (11, 13).

Relative contraindications

1. Obesity is usually associated with decreased fitness levels. Obese individuals assume an increased theoretical risk of decompression sickness, since nitrogen is five times more soluble in adipose tissue than in water. Whether or not this is of practical importance remains unclear.
Obesity is related to skinfold thickness (as measured by Harpenden skinfold calipers). Measurements are made below the scapula, over the triceps or biceps, and over the iliac crest, since abdominal fat is not necessarily a good indicator of obesity (4, 11).

Some sources recommend disqualification if the diver’s weight is 15%–20% over the recommended weight on currently accepted height-age tables (4, 7, 8, 12). Accepted tables can be found in several references (12, 44, 45). For added safety, obese sport divers can be limited to no-decompression diving and reduced bottom times (25%–50% of recommended time) (4).

2. Diving in cold water entails an increased risk of decompression sickness (1, 2, 4, 5) and cardiac problems (see Thermal Stress above). Any disease that is exacerbated by cold or that decreases the body’s tolerance for cold might be grounds for disqualification: Raynaud’s disease; Hypothyroidism; Addison’s disease.

Hematologic and immune system

Absolute contraindications

1. Sickle cell anemia (13).—Dysbaric osteonecrosis is associated with sickle cell anemia. Sickling can be precipitated by hypoxia or cold, two recognized hazards of the diving environment. A sickling crisis while under pressure could exacerbate or precipitate decompression sickness.

2. Hemophilia.—Previous articular damage may increase the probability of Type I decompression sickness. The hemophilic represents an increased trauma risk. Barotrauma (squeeze) could precipitate a serious bleed. Coagulation disorders may impact in unpredictable ways on decompression sickness.

3. Any other blood dyscrasia or anemia should be grounds for disqualification pending identification of the cause and results of treatment.

Relative contraindications

1. Sickle cell trait (7, 8, 11–13) has traditionally been grounds for disqualification of commercial divers, but this policy is currently under dispute (personal communication from Dr. David Elliott). Some candidates with sickle cell trait have been cleared for diving in the U.S. Navy, and no problems have been reported to date (32).

2. Leukemia and other forms of active malignancy (10): commercial and military divers should probably be disqualified if they exhibit evidence of any active malignancy. Sport divers deserve more leniency. A decision to clear such a diver must take into consideration the status of the circulatory system, including the lymphatics because lymphatic involvement may retard lymph flow and predispose to lymphatic decompression sickness. The physician should also be alert to signs of compromise of neurological or motor control. Individuals undergoing chemotherapy should probably be discouraged from diving (Author’s opinion).

3. Allergy: a severely atopic individual may be particularly susceptible to envenomation from marine creatures. Those individuals exhibiting allergic reactions to pollens, danders, and so forth should be careful where they dive, particularly in fresh water lakes and ponds that may have adjoining plan life.
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Neurological system

Type II (serious or neurological) decompression sickness as well as air embolism can present as subtle or gross neurological deficits. Therefore, it is imperative to thoroughly examine and document the diver’s neurological status. Normal anisocoria or asymmetrical deep tendon reflexes should be spotted and recorded before there is a problem. Any lesions that could compromise consciousness, judgment, motor control, or diagnosis should be considered potentially disqualifying.

Workup

A careful history and physical examination, with meticulous documentation, should be performed. The following points should be stressed:

1. Testing of the cranial nerves (C.N. I–XII).
2. Testing for deep tendon reflexes.
3. Testing for the presence of a Babinski reflex.
4. Testing for touch, pain, vibration, and two-point perception.
5. Testing for cerebellar function, including proprioception, dysdiadochokinesia, gait, and Romberg’s sign.
7. Testing for motor control and muscular strength.
8. A baseline electroencephalogram has been suggested for mixed gas divers (10), but most authorities do not recommend this as a routine procedure.

Absolute contraindications (4, 7, 10, 11, 15, 32)

1. Any demyelinating process, such as multiple sclerosis.
2. Brain tumor.
3. History of cerebrovascular accident or transient ischemic attack.
4. Intracranial aneurysm, arteriovenous malformation, or stenosis of a major cranial artery.
5. Narcolepsy.
6. Unexplained syncope.
7. Seizure disorders (epilepsy), except febrile convulsions of childhood. An epileptic who requires drugs should not be allowed to dive. Hyperventilation and hyperbaric oxygen can precipitate a seizure (32). Individuals who have had seizure disorders as children and who have stopped taking medication for several years without recurrence might be allowed to dive provided they have a normal electroencephalogram during hyperventilation. Nevertheless, there is little experience with such patients as divers, and clearing these individuals is controversial (32).
8. A history of neurologic (Type II) decompression sickness with residual deficit.
10. Head injury with sequelae, such as post-traumatic epilepsy.
12. Severe motion sickness. The risk of vomiting underwater with consequent aspiration and drowning is high. Motion sickness can impair judgment. An afflicted individual may be tempted to forego decompression stops to expedite return to the surface.
13. Sleepwalking should be disqualifying for commercial or military divers, but is not necessarily so for sport divers, depending on circumstances.
14. Migraine headache. Scintillating scotoma and other visual symptoms can be confused with the symptoms of decompression sickness or air embolism. Migraine can be exacerbated by diving (4, 46). Migraine can provoke vertigo and vomiting (46). Individuals who experience migraine headaches may be taking beta-blockers or clonidine (46), which could affect exercise and cold tolerance. Although migraine is generally cause for the disqualification of commercial or military divers, it may or may not disqualify sport divers, depending on the frequency, pattern, and severity of previous attacks (4, 5, 46).

Relative contraindications

1. Post gas embolism or Type II decompression sickness without residual deficits (see Post Type I decompression sickness above):
   - U.S. Navy policy requires a 4 wk lay-off before returning to diving (1).
   - British policy requires a 7-d lay-off (or longer, as determined after examination by an "Approved Doctor") (35).
2. Headache. The diver should wait for complete resolution.
3. Spasticity, weakness, or paralysis of the extremities. This is generally cause for disqualification of commercial and military divers. Paraplegics who are sport divers may be qualified if certain limitations are imposed. This might include diving with a buddy to prevent injury to trailing legs on coral, etc.
4. Any neurological symptoms or complaints should be resolved before an individual is allowed to participate in diving.

Psychiatric examination

This is one of the most important aspects of the medical examination, yet it is also the most elusive. Divers should be mature, emotionally stable individuals who are capable of good judgment. The ability to live and work in isolation and in enclosed spaces is critical for commercial and military divers, as well as for individuals engaged in caisson work.

Workup

A psychiatric history should be obtained that is as complete as circumstances and interviewer training will allow.
1. The physician should try to elicit a history of previous psychiatric illness or treatment.
2. The candidate should be questioned about his sleep pattern.
3. A social and occupational history might provide clues suggesting personality disorders.
4. Check the candidate's driver's license for traffic violations that could suggest drug abuse, alcoholism, poor judgment, etc.
5. Questioning about prior military service may be helpful in elucidating various character traits.
6. The candidate's affect in response to the examiner's questions should be noted.
7. The examiner should be alert for the possibility of dissimulation.

Absolute contraindications (5, 7, 10, Author's opinion)

1. Claustrophobia.
2. Suicidal ideation.
3. Psychosis.
4. Certain neuroses. The examiner should weigh the hazards of the diving environment against the possible impact any neurotic behavior might have on the diver's judgment.
5. Anxiety states.
6. Severe depression.
7. Manic states.
8. Social drug use (hallucinogens, opiates, etc.).

ANCILLARY INVESTIGATIONS

Physical work capacity

Exercise tolerance tests are very useful for the assessment of diver fitness (7, 8). Two such tests are provided:

1. The Astrand and Rodahl submaximal exercise test (47) is performed on a bicycle ergometer. It is based on the steady-state heart rate achieved after 5–6 min of exercise at at least two different workloads. Tables or nomograms are then used to predict maximum oxygen consumption. The results must be age corrected.
   Minimum standards in milliliters of oxygen per kilogram per minute (8):
   - 45 ml·kg⁻¹·min⁻¹ under 30 yr of age;
   - 40 ml·kg⁻¹·min⁻¹ over 30 yr of age.

2. British Army Fitness Test (7, 8). The candidate is required to step on and off a 43-cm (17-inch) stool for 5 min at a rate of 30 steps per min. A 30-s duration pulse count is taken successively 1, 2, and 3 min after cessation of the test (P1, P2, P3). The sum of the counts (P1 + P2 + P3) should be less than 190 beats.

Pressure test

A pressure test is required by the U.S. Navy of candidates for diving training and would seem to be desirable if facilities are available (15). The U.S. Navy test entails taking the candidate to 34 m (112 fsw) at a rate that the candidate can tolerate. Decompression takes place at a rate not to exceed 18.3 m/min (60 ft/min).

Oxygen tolerance test

This is a standard test in the U.S. Navy (15). The candidate breathes 100% oxygen at 18.3 m (60 fsw) for 30 min and is observed for symptoms of oxygen toxicity (visual disturbance, nausea, fasciculations and muscle twitching, paresthesias, tinnitus, and irritability).

In 1947, Donald (48) found an enormous variation in oxygen tolerance among different subjects exposed to the same environmental conditions, as well as considerable day-to-day variability in the same subject. This research has led many to conclude that an oxygen tolerance test has no predictive value and that its use for routine screening of divers should be abandoned.
Laboratory examinations

Proposed NIOSH standards (10)

Urinalysis.
VDRL (or any test for syphilis).
Complete blood count.
Blood type, Rh factor, and hemoglobin abnormality testing on initial examination.

U.S. Navy standards (15)

Complete blood count.
Urinalysis.
Standard serum chemistries including electrolytes and enzymes for divers over 40.
Fasting blood sugar for divers over 40.

European standards (7, 8, 12)

Erythrocyte sedimentation rate must be less than 12 mm/h.
Complete blood count
Hematocrit must be at least 40%
Hemoglobin must be at least 12 g/100 ml.
Check for sickle cell trait.
Blood typing must be performed on initial examination.
Urinalysis.

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embolie gazeuse actions réciproques des drogues
arythmie hypothermie
barotraumatisme immersion
plongée Médecine de la marine
noyade ostéonécrose

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