

Scuba Diving and Ophthalmology



Shawn Cohen

MDCM, FRCSC, DABO
Assistant Professor of Ophthalmology
McGill University



Reference

- ◆ Diving and Hyperbaric Ophthalmology
(Major Review)
- ◆ Captain Frank K. Butler, Jr., MD
- ◆ Survey of Ophthalmology 39: 347-366, 1995
- ◆ Online Summary:
 - ◆ <http://scuba-doc.com/diveye.htm>

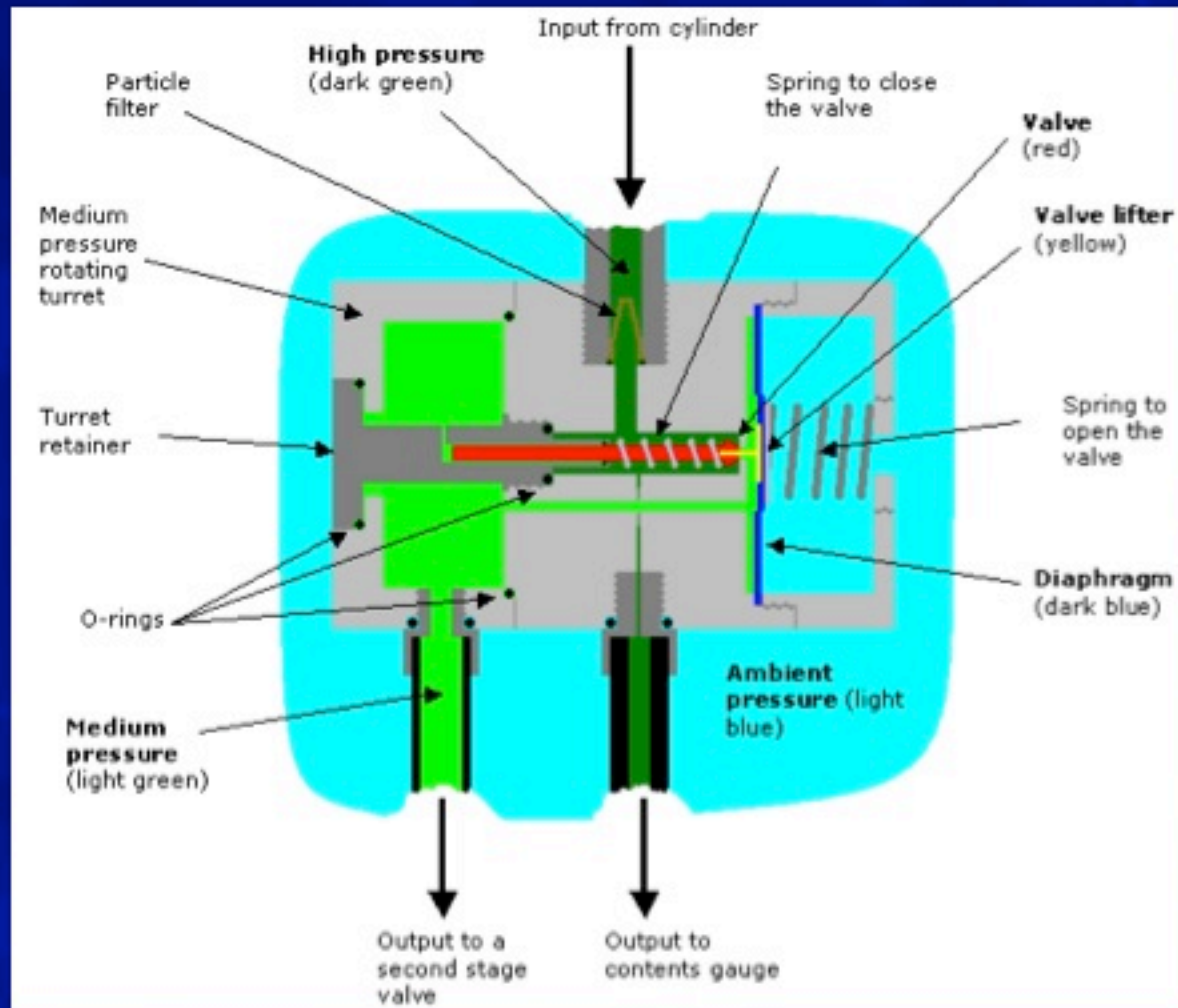


SCUBA

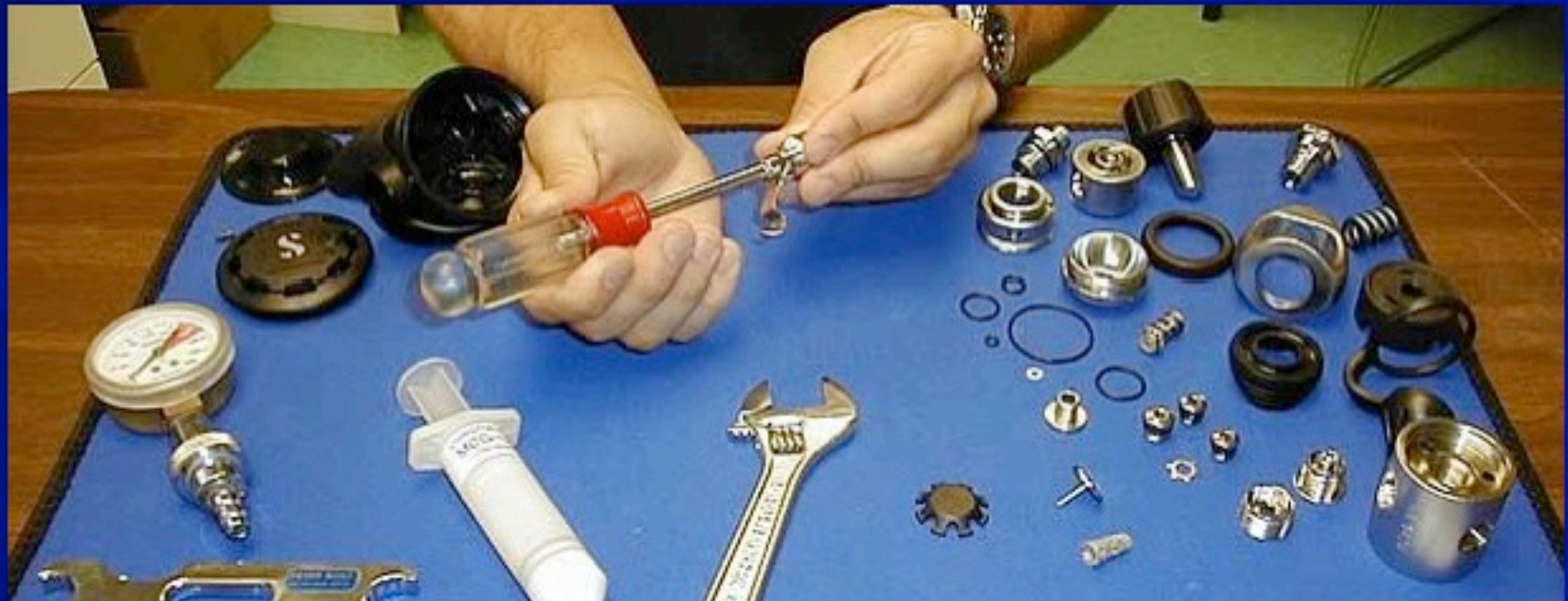
Self-Contained Underwater Breathing Apparatus



Regulator (Diaphragm, 1st Stage)



Regulator Maintenance



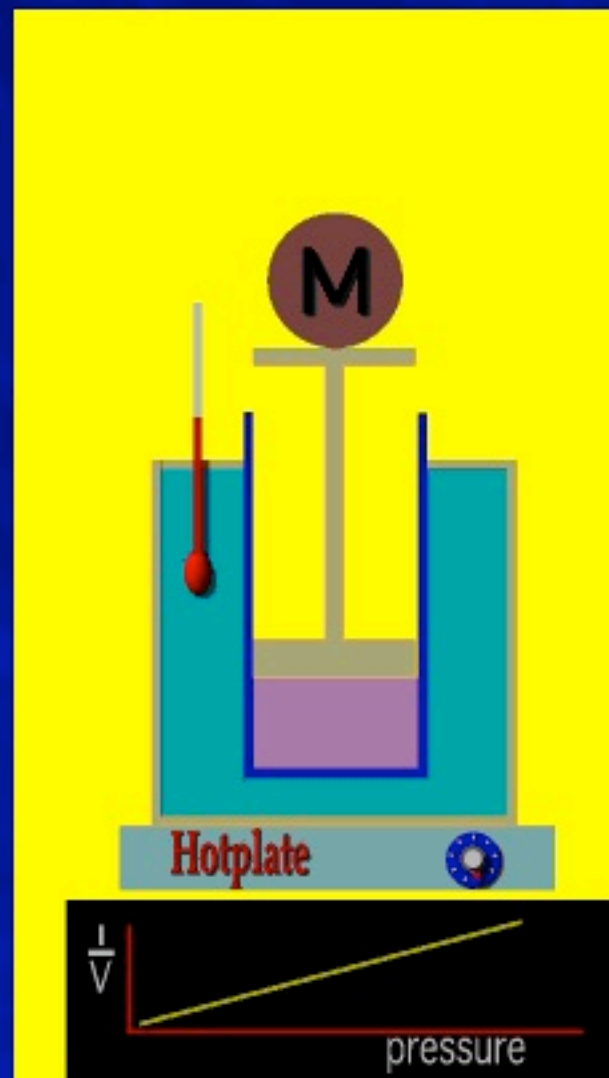
Rebreather

- ◆ Open, semi-closed, closed circuits
- ◆ Open: CO₂ exhaled in bubbles
 - ◆ Inefficient use of O₂, worsens with depth
- ◆ Closed circuit rebreather (CCR):
 - ◆ Counterlung for expansion, volume mvt
 - ◆ CO₂ absorber (LiOH...)
 - ◆ O₂ regulator
 - ◆ Upstream and downstream check valves
 - ◆ Shut-off valve (H₂O exposure)



Boyle's Law

- ◆ $P_1V_1 = P_2V_2$ or
- ◆ $P_1V_1 = \text{Constant}$
- ◆ Temperature is constant

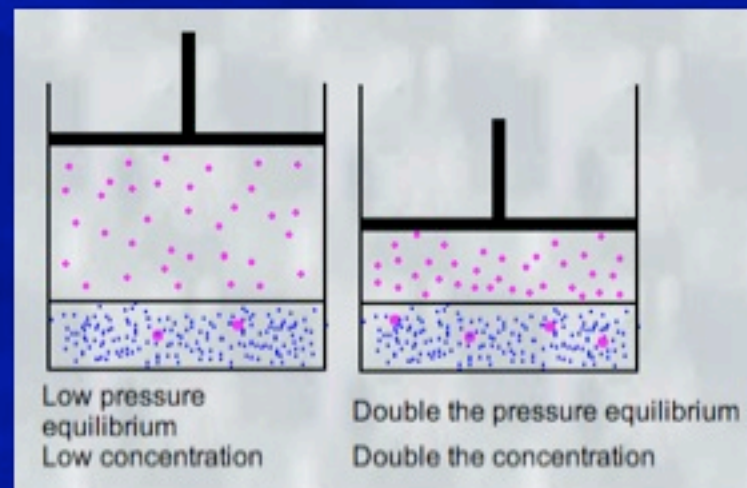


SCUBA Diving

- ◆ Boyle's Law ($P_1V_1 = P_2V_2 = \text{Constant}$)
 - ◆ Temperature is constant
 - ◆ During descent, P increases so V decreases
 - ◆ Eg. Face mask barotrauma / sucking
 - ◆ Re-expansion occurs during ascent
 - ◆ Eg. Intraocular gas expansion / CRAO; Lung rupture
- ◆ Henry's Law of gas solubility in liquids
 - ◆ Eg. Decompression sickness

$$P_{\text{gas}} = kC \text{ at constant } T$$

$$\frac{C_1}{P_1} = \frac{C_2}{P_2}$$



Face Mask Barotrauma

- ◆ Compression of the air in the mask results in a relative vacuum



TABLE 4

Ophthalmic Contraindications to Diving

1. Intraocular gas
2. Presence of a hollow orbital implant
3. Any acute infectious or inflammatory ocular disorder which produces significant pain, photophobia, diplopia, or decrease in vision
4. Recent ophthalmic surgery prior to completion of the recommended convalescent period
5. Inadequate vision to function safely in the underwater environment
6. Visually significant deficits from previous episodes of decompression sickness or arterial gas embolism
7. Functioning glaucoma filter (relative contraindication)

TABLE 3

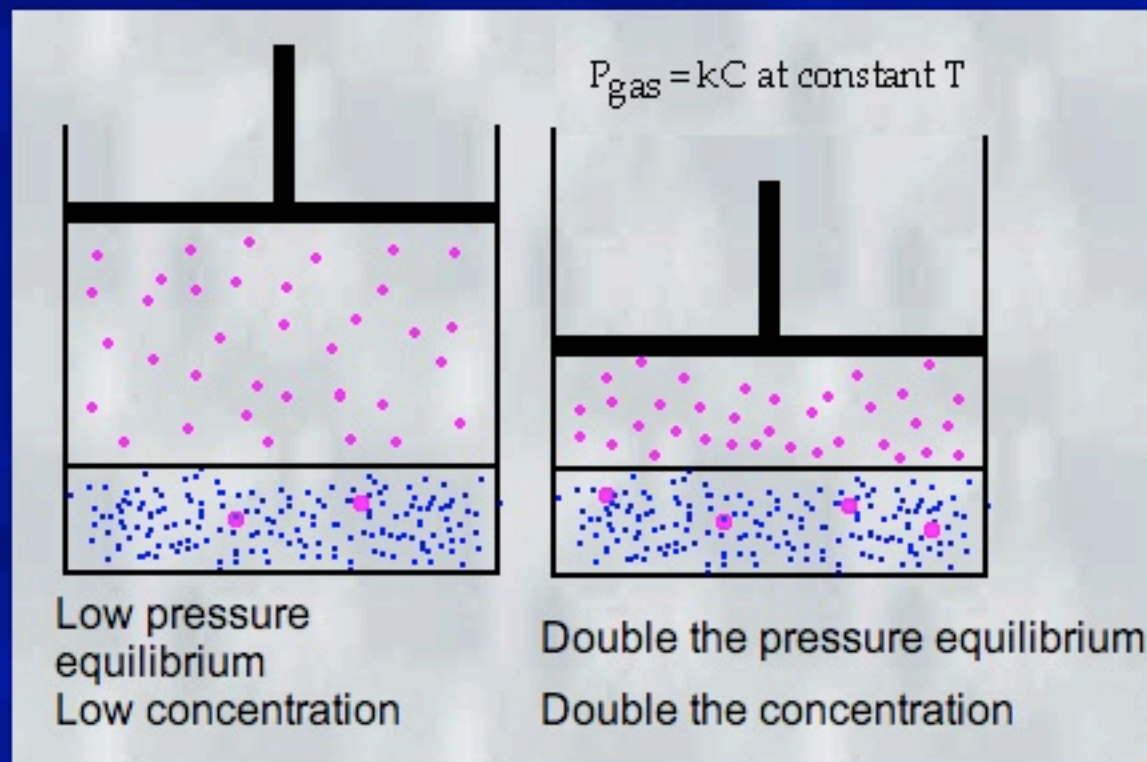
Recommended Minimum Convalescent Periods Prior to Diving after Ophthalmic Surgery

Procedure	Recommended Convalescent Period
<i>Anterior segment surgery</i>	
Penetrating keratoplasty	6 months
Corneal laceration repair	6 months
Cataract surgery	
Non-corneal valve incision	3 months
Corneal valve incisions	
Clear corneal	2 months
Scleral tunnel	1 month
Radial keratotomy	3 months
Astigmatic keratotomy	3 months
Glaucoma filtering surgery	2 months
	(Relative contraindication)
Photorefractive keratectomy	2 weeks
Pterygium excision	2 weeks
Conjunctival surgery	2 weeks
Corneal suture removal	1 week
Argon laser trabeculoplasty or iridectomy	No wait necessary
Yag laser capsulotomy	No wait necessary
<i>Vitreoretinal surgery</i>	
Vitreotomy	2 months
	(Diving contraindicated until intraocular gas resorbed)
Retinal detachment repair	2 months
Pneumatic retinopexy	2 months
	(Diving contraindicated until intraocular gas resorbed)
Retinal cryopexy or laser photocoagulation for breaks	2 weeks
<i>Oculoplastic surgery</i>	
Sutured wound	2 weeks
Skin graft or granulating wound	Until epithelialization is complete
Enucleation	2 weeks
	(Diving contraindicated with hollow orbital implants)
<i>Strabismus surgery</i>	2 weeks

Henry's Law

◆ Solubility of gases in liquids

- ◆ Nitrox 78% N₂, 21% O₂
- ◆ Less toxicity, fewer decomp. stops, less fire hazard than high O₂



$$\frac{C_1}{P_1} = \frac{C_2}{P_2}$$

Decompression Sickness

Table 1. Signs and symptoms of decompression sickness.

DCS Type	Bubble Location	Signs & Symptoms (Clinical Manifestations)
BENDS	Mostly large joints of the body (elbows, shoulders, hip, wrists, knees, ankles)	<ul style="list-style-type: none"> ▫ Localized deep pain, ranging from mild (a "niggle") to excruciating. Sometimes a dull ache, but rarely a sharp pain. ▫ Active and passive motion of the joint aggravates the pain. ▫ The pain may be reduced by bending the joint to find a more comfortable position. ▫ If caused by altitude, pain can occur immediately or up to many hours later.
NEUROLOGIC	Brain	<ul style="list-style-type: none"> ▫ Confusion or memory loss ▫ Headache ▫ Spots in visual field (<i>scotoma</i>), tunnel vision, double vision (<i>diplopia</i>), or blurry vision ▫ Unexplained extreme fatigue or behaviour changes ▫ Seizures, dizziness, <i>vertigo</i>, <i>nausea</i>, <i>vomiting</i> and unconsciousness may occur, mainly due to <i>labyrinthitis</i>
	Spinal Cord	<ul style="list-style-type: none"> ▫ Abnormal sensations such as burning, stinging, and tingling around the lower chest and back ▫ Symptoms may spread from the feet up and may be accompanied by ascending weakness or <i>paralysis</i> ▫ Girdling abdominal or chest pain
	Peripheral Nerves	<ul style="list-style-type: none"> ▫ Urinary and rectal <i>incontinence</i> ▫ Abnormal sensations, such as numbness, burning, stinging and tingling (<i>paresthesia</i>) ▫ Muscle weakness or twitching
CHOKES	Lungs	<ul style="list-style-type: none"> ▫ Burning deep chest pain (under the <i>sternum</i>) ▫ Pain is aggravated by breathing ▫ Shortness of breath (<i>dyspnea</i>) ▫ Dry constant cough
SKIN BENDS	Skin	<ul style="list-style-type: none"> ▫ Itching usually around the ears, face, neck arms, and upper torso ▫ Sensation of tiny insects crawling over the skin ▫ Mottled or marbled skin usually around the shoulders, upper chest and abdomen, with itching ▫ Swelling of the skin, accompanied by tiny scar-like skin depressions (<i>pitting edema</i>)

Decompression Sickness

TABLE 1

Ocular Manifestations of Decompression Sickness

1. Nystagmus
 2. Diplopia
 3. Visual field defects
 4. Scotoma
 5. Homonymous hemianopia
 6. Orbicularis oculi pain
 7. Cortical blindness
 8. Convergence insufficiency
 9. Central retinal artery occlusion
 10. Optic neuropathy
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Altitude DCS!

- ◆ In excess of 18,000 feet (standard commercial flight!)
- ◆ O2 mask 100%O2
- ◆ Emergency decent (Continue O2!)
 - ◆ Resolution confirms the diagnosis! So, don't stop Rx!
- ◆ If joint pain occurs, keep the area still
- ◆ Be your own advocate; hyperbaric specialists are rare!
- ◆ Delayed onset of symptoms can occur
- ◆ Do not fly for 24 hours after the event
- ◆ Always allow min. 24 hours between flight and diving
- ◆ Divers Alert Network (DAN) (USA) 919-684-4DAN



Causes of Acutely Decreased Vision After Diving (Table 2)

- ◆ Decompression sickness
- ◆ Arterial gas embolism
- ◆ Displaced contact lens
- ◆ Anti-fog keratopathy
- ◆ Ultraviolet keratitis
- ◆ Corneal edema from bubbles under PMMA or RGP contact lenses
- ◆ Contact lens adherence syndrome

Thank You