Scuba diving-related Pulmonary Edema

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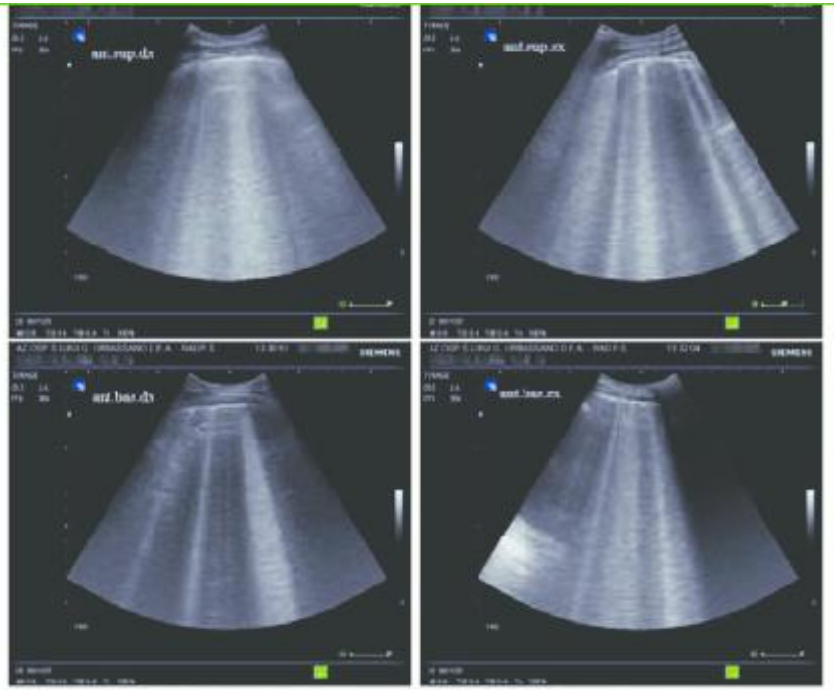
SC Pronto Soccorso e Medicina d'Urgenza ASL 5 Spezzino



M.S, maschio 32 anni
Corpi speciali MM
Nuoto orizzontale (7 mt prof.)
T acqua 13°

Dispnea ingravescente
HR 90 btt/min
AP 160/90 mmHg

pH 7,31
pCO2 53
pO2 130
FiO2 60%

P/F 216

C-PAP + 12,5 cmH2O, FiO2 40%
→ pO2 180
→ Nitrati ev
→ Furosemide

M.S, maschio 29 anni
Corpi speciali MM

Dispnea e tosse ingravescente

pH 7,38
pCO2 44
pO2 58
FiO2 21%


ATLANTIC
SCALA HO
SOMMOZZATORI D'ITALIA

Pulmonary Edema Associated With Scuba Diving*

(CHEST 2001; 120:1686–1694)

John B. Slade, Jr, MD; Takashi Hattori, MD,

Case Reports and Review

Wilmshurst et al: Cold-induced pulmonary oedema in scuba divers and swimmers and subsequent development of hypertension. ***Lancet 1989;1:62-5***

Pons et al: Pulmonary oedema in healthy persons during scuba-diving and swimming. ***Eur Respir J 1995;8:762-7***

Miller et al: Swimming–induced pulmonary edema in triathletes. ***Am J Emerg Med 2010;28:941-6***

"….Symptom history compatible with SIPE was identified in ***1.4 % of the population***…"

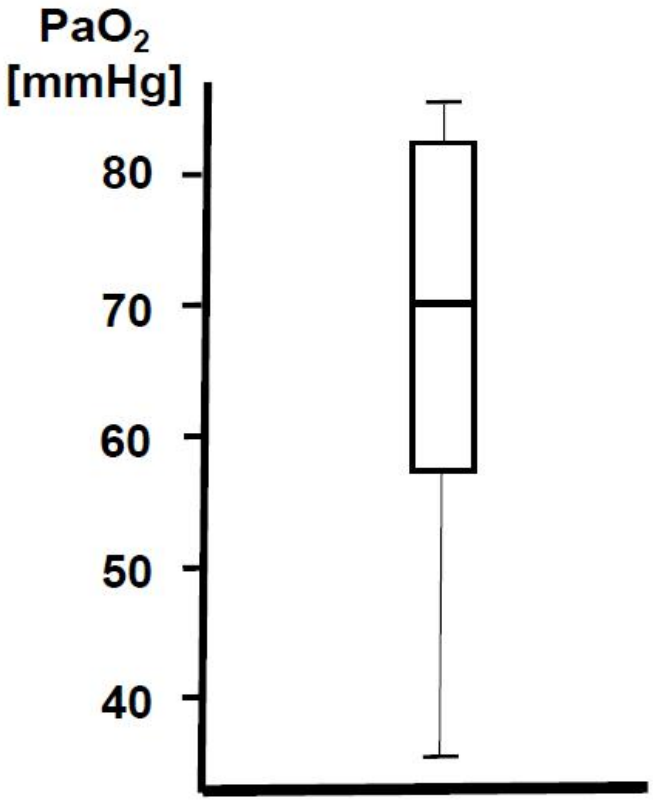
Moon et al: Swimming-induced pulmonary edema. ***Circulation 2016;133:988-96***

"….***300 cases*** have since been published…"

Presentazione

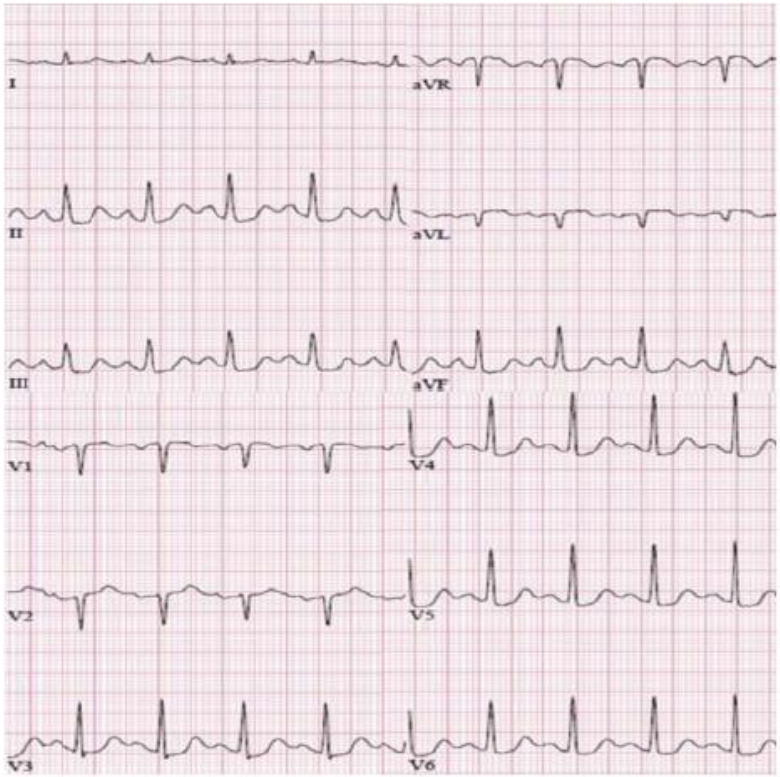
Koehle et al:
Pulmonary oedema of immersion.
Sports Med 2005;35:183-90

Coulange et al:
Pulmonary oedema in healthy SCUBA divers: new physiopathological pathways. *Clin Physiol Funct Imaging 2010;30:181-6*

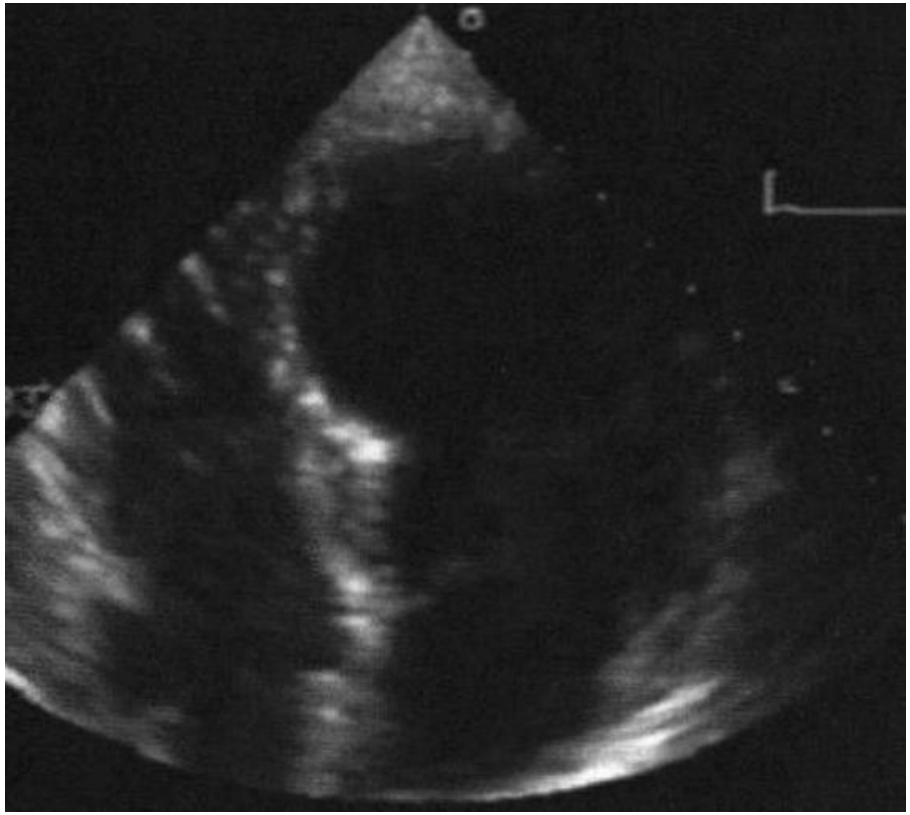


PaO_2 [mmHg]	Troponin [ng/mL] (< 0,2)	BNP [ng/L] (< 100)
68 ± 11 (48 – 90)	0.33 ± 0.51 (0.01 – 1.47)	223 ± 221

Presentazione



Baber et al:
Stress cardiomyopathy caûsed by diving:
case report and review of the literature.
J Emerg Med 2016;50:277-80



Shearer et al:

Brain natriuretic peptide levels in 6 basic underwater demolition/SEAL recruits presenting with swimming induced pulmonary edema (SIPE).

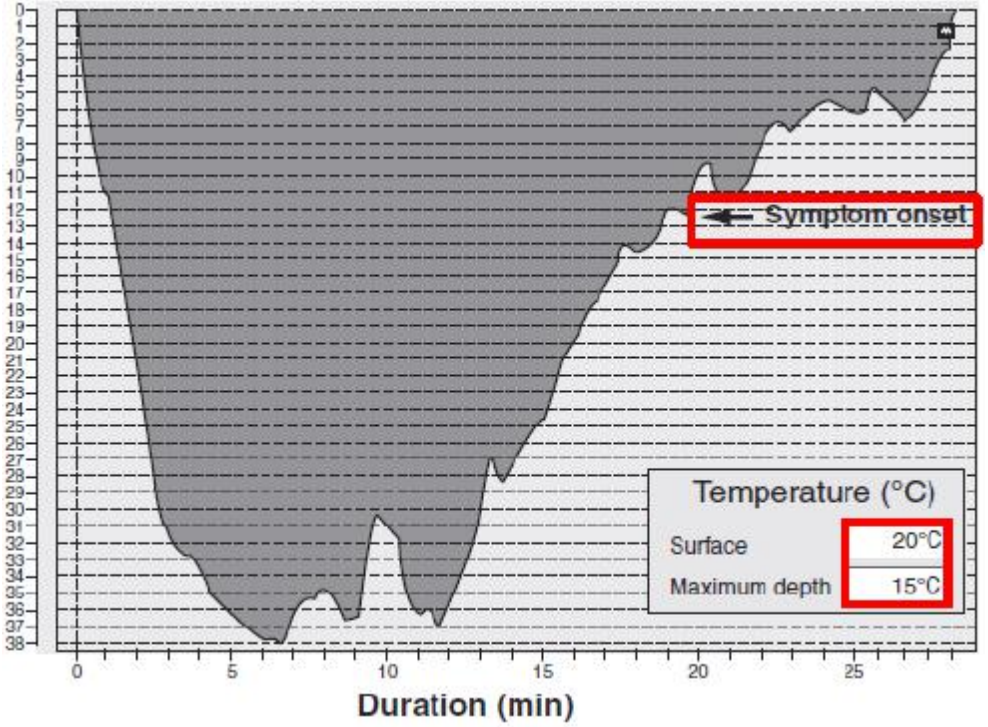
J Spec Oper Med 2009;9:44-50

Onset 5-45 min after start of swimming

Coulange et al:

Pulmonary oedema in healthy SCUBA divers: new physiopathological pathways.

Clin Physiol Funct Imaging 2010;30:181-6



frontiers in Physiology

REVIEW
published: 31 August 2017
doi: 10.3389/fphys.2017.00652

Diagnosis of Swimming Induced Pulmonary Edema—A Review

*Hannes Grünig[1], Pantelis T. Nikolaidis[2], Richard E. Moon[3] and Beat Knechtle[4,5]**

TABLE 2 | Diagnostic checkpoints and management of SIPE.

History	Exercise in cold water
	Absence of water aspiration
	Absence of diseases concerning the cardiopulmonary system
	Acute onset of symptoms during or immediately after swimming
Symptoms	Cough and/or dyspnoea and/or chest tightness
	Haemoptysis
Clinical findings	Auscultation suggesting airway process (cracles, rales, wheezing)
Diagnostic testing	Hypoxemia[a]
	Radiological findings compatible with pulmonary edema

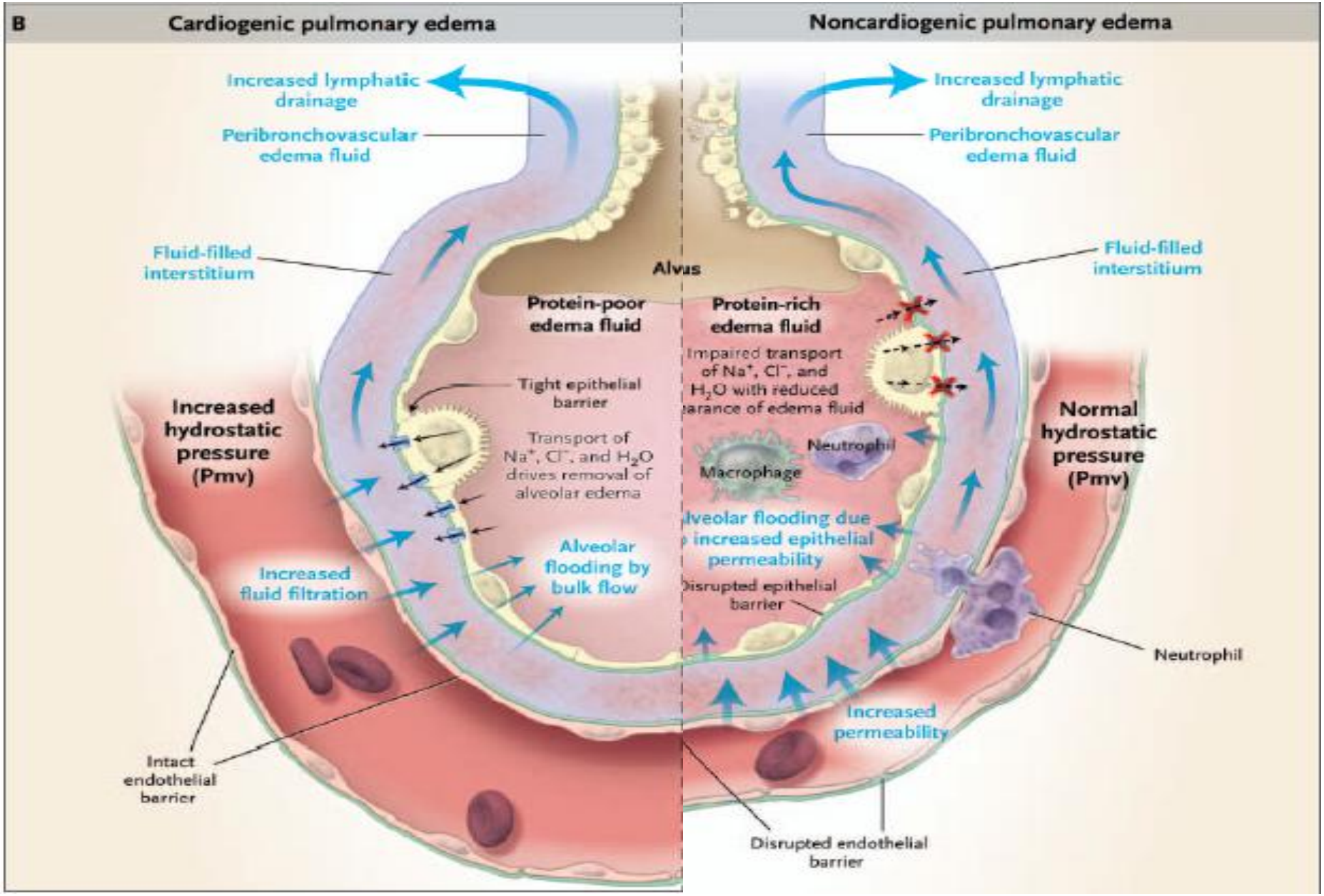
Fisiopatologia

- ***Genesi mista***

1) Emodinamica

2) Lesionale

3) High altitude pulmonary edema (HAPE)



N Engl J Med 2005;353:2788-96.

Immersione

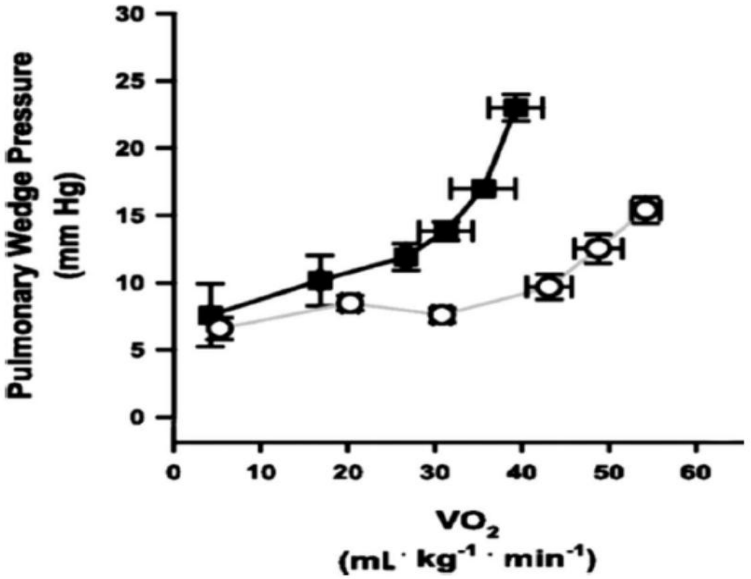
Immersion Pulmonary Edema in Special Forces Combat Swimmers

Mahon RT et al. Chest 2002; 122: 383-4

……Recently, three combat swimmers between the ages of 22 years and 28 years, without previous medical problems, simultaneously presented with unilateral radiographic findings of pulmonary Edema…. Varying degrees of hypoxemia, tachypnea, and unilateral crackles (two right-sided and one left-sided) were observed. Radiographic findings included unilateral Kerley-B lines,….. swim primarily in a lateral decubitus position to allow constant eye contact with a partner…. The dependent submersed lung was the radiographically affected lung

We believe that unilateral pulmonary edema, as observed in these combat swimmers, reflected global and regional pulmonary vascular changes that led to stress failure of the capillary bed.

1) ↑ Ritorno venoso
2) ↑ Pre-load
3) ↑ PAP
4) ↑ attività simpatica
5) ↑ After-load
6) ↑ Pressioni transmurali



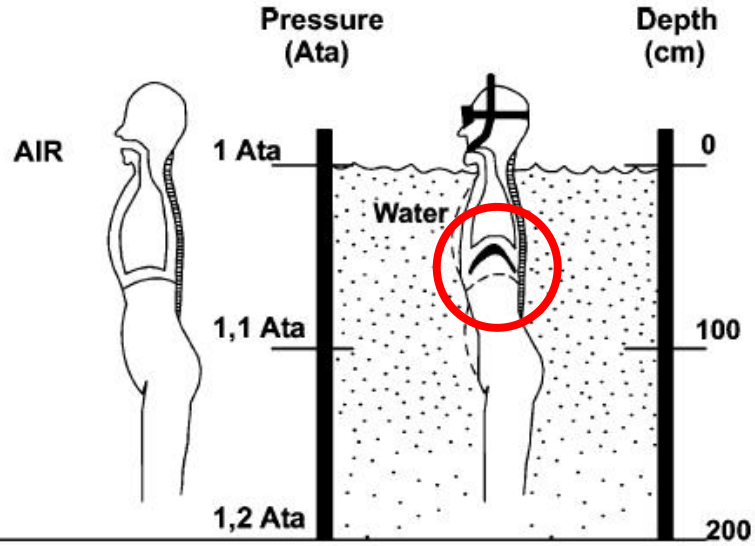
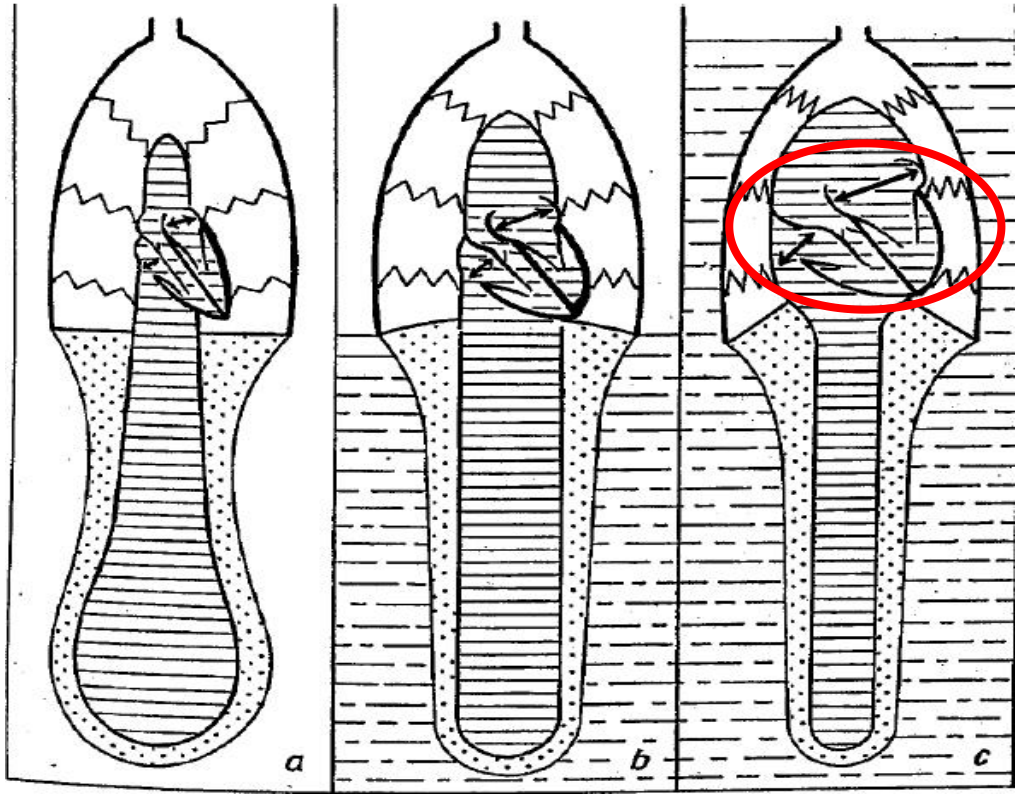


Fig. 2. Immersion effects. Immersion in water to the neck already leads to a reduction in lung volume, an elevation of the diaphragm (*right*) and a redistribution of blood into the thorax. With increasing depth, these effects are more pronounced. (*Modified from* Hong SK. Breath-hold diving. In: Bove AA, Davis JC, editors. Diving medicine. Philadelphia: W.B. Saunders; 1997. p. 66.)

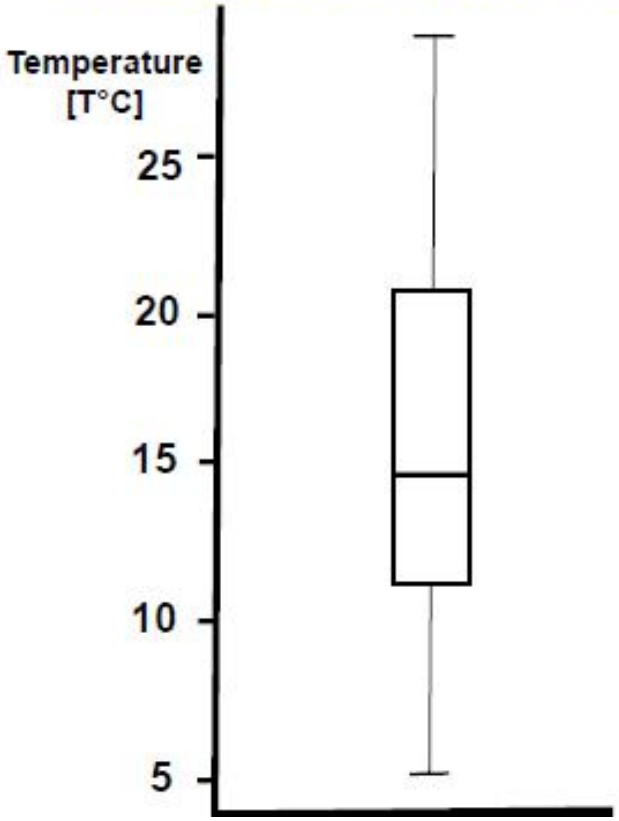


Arborelius et al:
Hemodynamic changes in man during immersion in water.
Aerospace Med 1972;43:592-8

	RAP [mmHg]	MAP [mmHg]	Heart rate [1/min]	SV [mL]
Dry	-2 ± 15	85 ± 8	74 ± 11	85 ± 18
Wet	5 ± 3	97 ± 11	70 ± 10	108 ± 21

Temperatura?

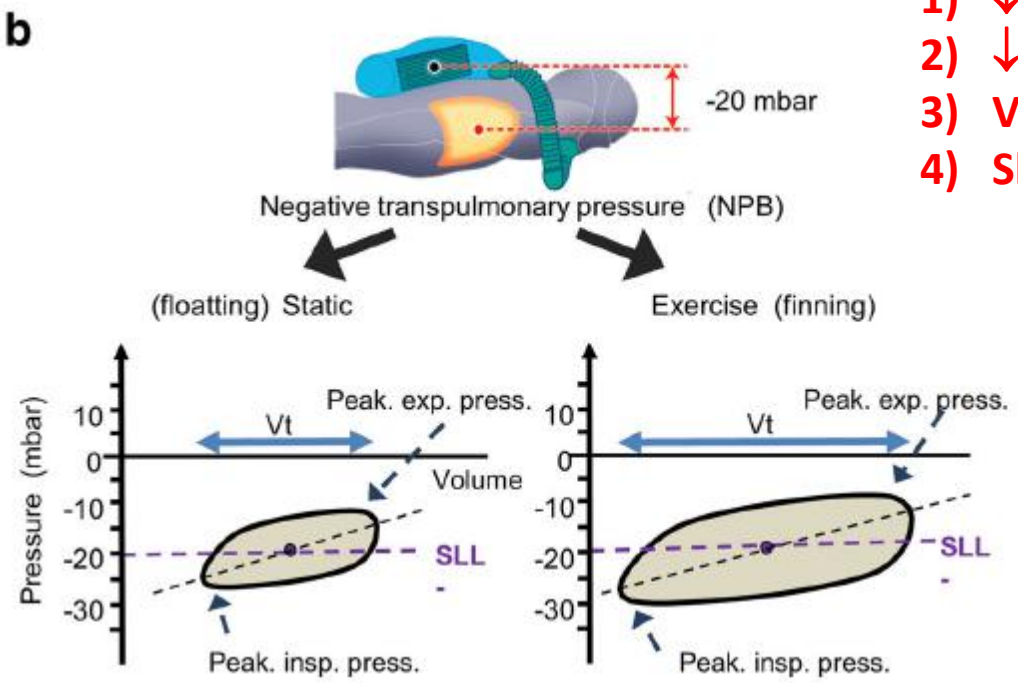
Koehle et al:
Pulmonary oedema of immersion.
Sports Med 2005;35:183-90



Coulange et al:
Pulmonary oedema in healthy SCUBA divers: new physiopathological pathways.
Clin Physiol Funct Imaging 2010;30:181-6

Depth [m]	Time [min]	Temp. [°C]
33 ± 12 (10 – 63)	**27** ± 8 (15 – 42)	**16** ± 4 (13 – 27)

1) ↓ capacità vitale
2) ↓ CFR
3) Vasocostrizione polmonare non uniforme
4) Shift endoalveolare



APPARATO RESPIRATORIO ED IMMERSIONE CON AUTORESPIRATORE

- **Aumento della densità dell'aria**
- **Aumento delle resistenze e dello spazio morto**
- **Aumento della pressione idrostatica**
- **Alterazioni della meccanica respiratoria**
- **Necessità di elevate pressioni negative e positive per inspirare ed espirare**

EPA emodinamico

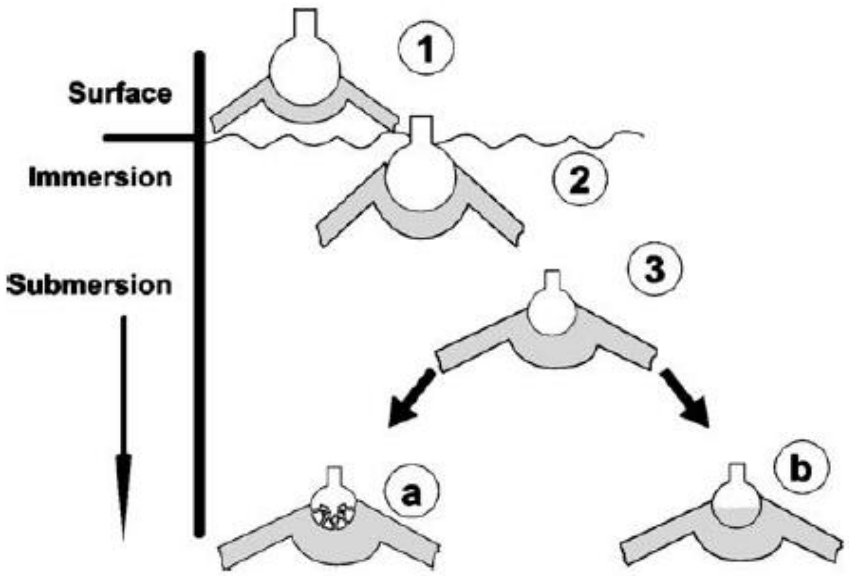


Fig. 3. Blood shift. At surface (1), the alveoli of the lung and the pulmonary blood vessels have their normal diameters. Immersion (2) to the neck creates a negative intrathoracic pressure and, thus, an increased venous return into the pulmonal vessels. Submersion while breath-holding (3) leads to a compression of alveoli (Boyle's law) and a further redistribution of blood into the thoracic vessels, leading to engorgement of these vessels. In greater depth, this mechanism may lead either to a rupture of vessels from overdistension (a) or to an intraalveolar edema (b) from the very high hydrostatic pressure.

HAPE model

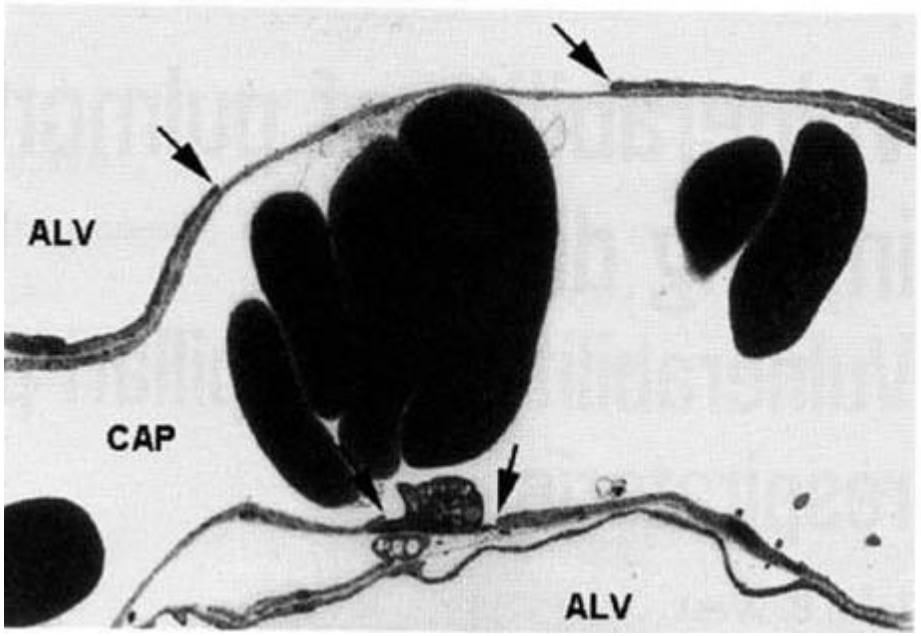
Vasocostrizione ipossica disomogenea

Overperfusion zone non vaso-costrette

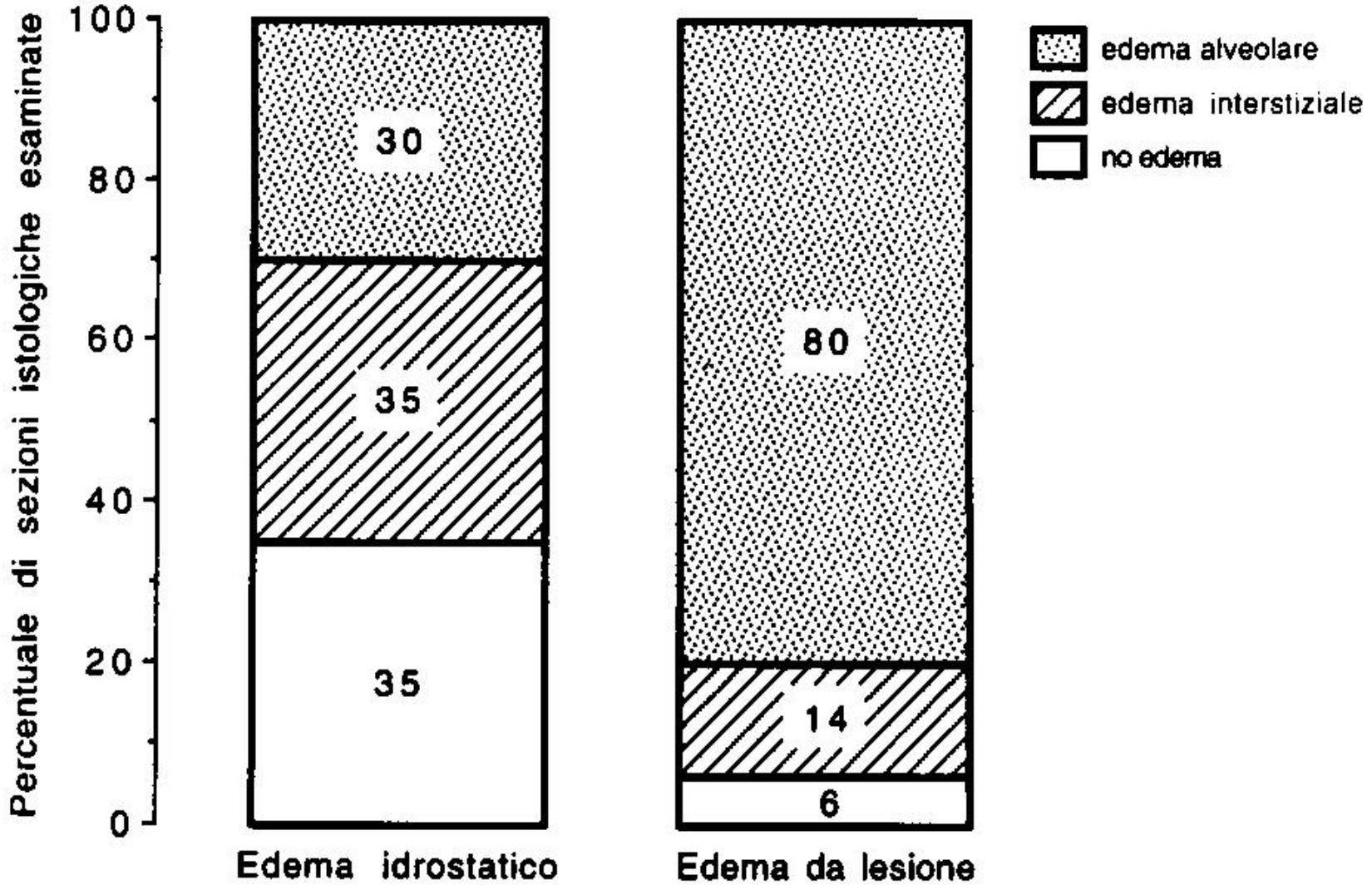
Danno barriera alveolo capillare

Passaggio proteine ed eritrociti

Distribuzione «anomala»



Differenziazione cardiogeno/lesionale



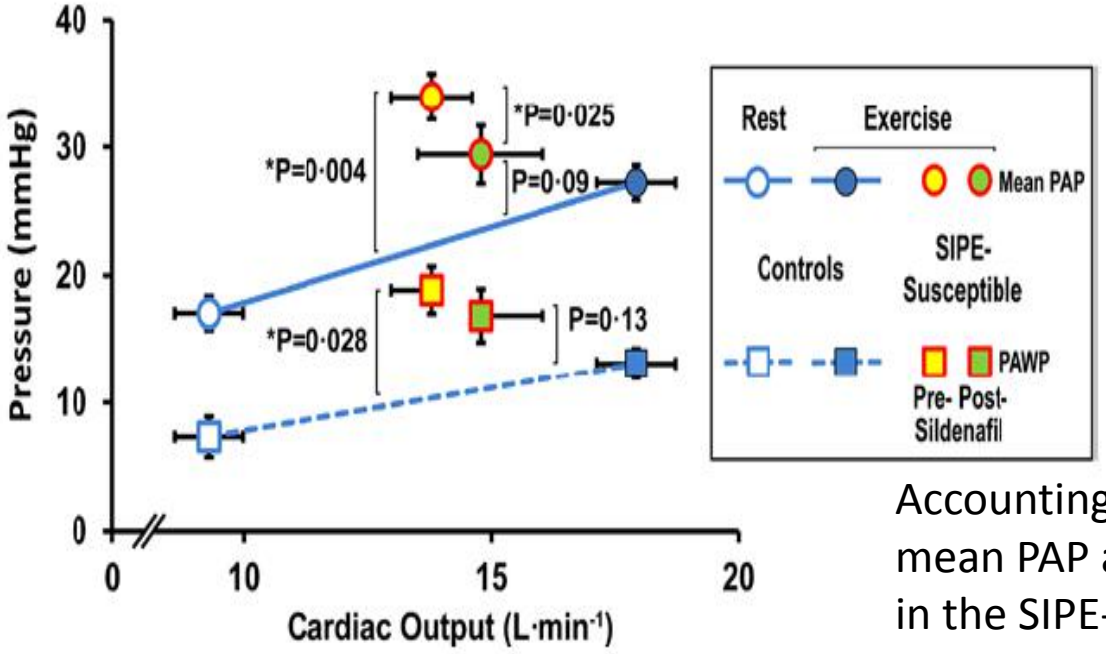
Montaner et al. J Clin Invest 1986

Swimming-Induced Pulmonary Edema Pathophysiology and Risk Reduction With Sildenafil

Richard E. Moon,

Circulation. 2016;133:988-996.

Conclusions—These observations confirm that SIPE is a form of hemodynamic pulmonary edema. The reduction in pulmonary vascular pressures after sildenafil with no adverse effect on exercise hemodynamics suggests that it may be useful in SIPE prevention.



Accounting for differences in cardiac output, mean PAP and PAWP were significantly higher in the SIPE-susceptible group than in controls (*P*=0.004 and *P*=0.028, respectively). After sildenafil, mean PAP was significantly reduced (*P*=0.025). During the postsildenafil exercise, neither mean PAP nor PAWP was significantly different from controls

Fattori di rischio

Gempp et al:
Reversible myocardial dysfunction and clinical outcome in scuba divers with immersion pulmonary edema.
Am J Cardiol 2013;111:1655-9

Age > 50
Art. Hypertension
Diabetes
Hypercholesterolemia
Phys./psych. Stress

Miller et al:
Swimming–induced pulmonary edema in triathletes.
Am J Emerg Med 2010;28:941-6

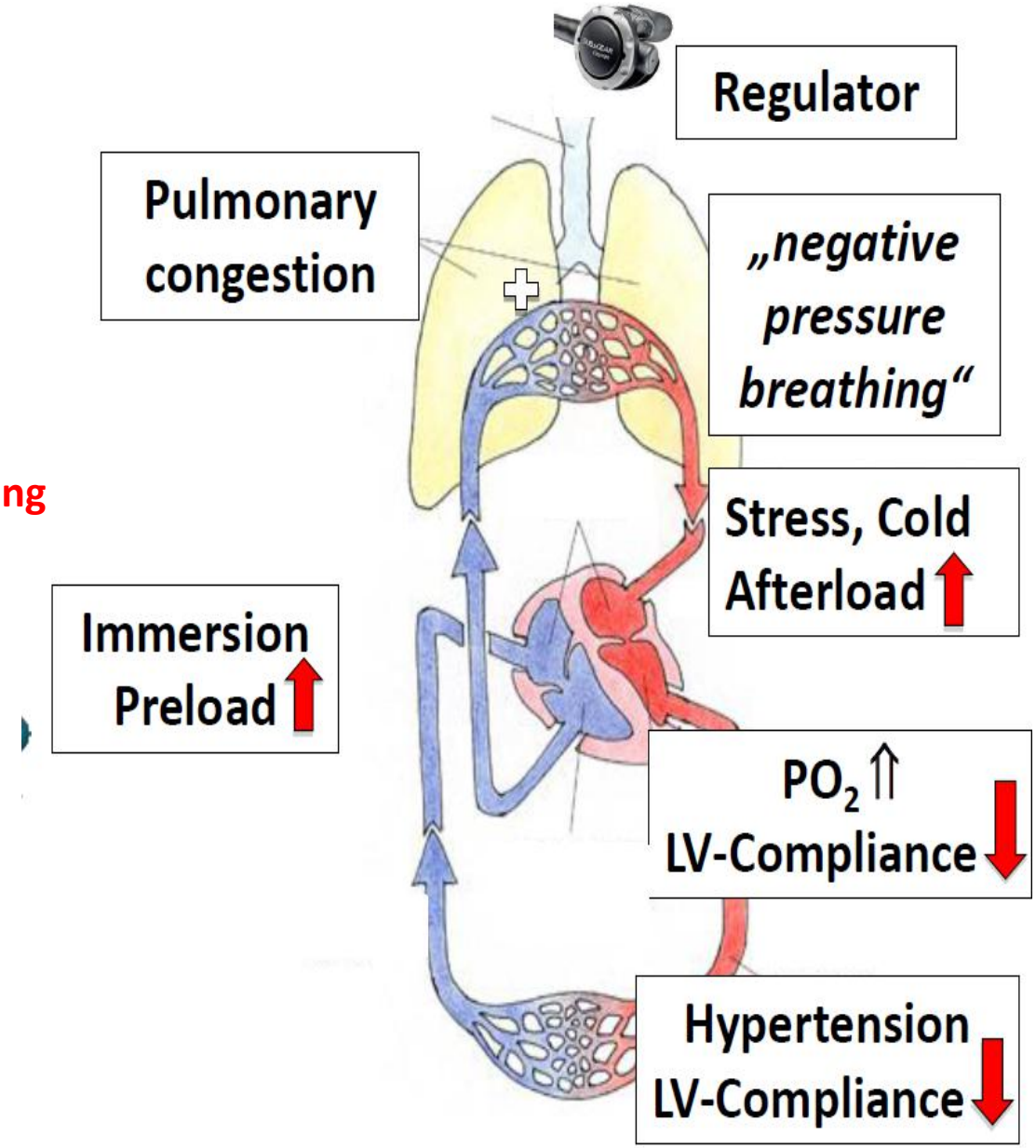
	> 2 x risk increase due to…
Age	50 - 59
Gender	Female
Course	≥ Half Ironman (2 km)
Chronic disease	Hypertension, Diabetes
Equipment	Neopren
Pre-hydration	> 1 L

Patologia recidivante

↑ tidal volume
↑ elevates right heart preload,
↑ triggering a right to left ventricular imbalance and lung congestion.

Exercising with negative press. breathing
↑ the inspiratory work of breathing,
↑ right ventricle loading,
↑ right to left heart imbalance,
↑ lung water accumulation.

↑Plasma levels of BNPde with inspiratory work and correlates with lung comet scores.

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Entertainment from
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HARRY SALTZMAN, ALBERT R. BROCCOLI
PRESENTANO
SEAN CONNERY
PANAVISION
TECHNICOLOR
REALIZZATO PER LA ARTISTS UNITED
"AGENTE 007-THUNDERBALL"
(OPERAZIONE TUONO)
TRATTO DA "THUNDERBALL" DI IAN FLEMING
CLAUDINE AUGER · ADOLFO CELI · LUCIANA PAOLUZZI
PRODOTTO DA KEVIN McCLORY
REGIA DI TERENCE YOUNG
RICHARD MAIBAUM, JOHN HOPKINS-KEVIN McCLORY, JACK WHITTINGHAM, IAN FLEMING