



# SILDENAFIL AS PROPHYLAXIS AGAINST SWIMMING-INDUCED PULMONARY EDEMA?

## A CASE REPORT

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### Abstract

**Introduction/Background:** Swimming-induced pulmonary edema (SIPE) occurs during swimming and scuba diving, usually in cold water, in susceptible healthy individuals, especially military recruits and triathletes<sup>1-3</sup>. We have previously demonstrated that pulmonary artery pressure (PAP) and pulmonary artery wedge pressure (PAWP) are higher during immersed exercise in SIPE-susceptible individuals vs. controls, and that oral sildenafil 50 mg 1 hour before immersed exercise reduces PAP and PWAP. This suggests that sildenafil may prevent SIPE.

**Materials and Methods:** A 46 year old female ultra-triathlete who had experienced at least 5 episodes of SIPE was instrumented with PA and radial artery catheters and studied during 6 minutes of prone exercise in 20°C water and during a dunk. Exercise was performed prior to administering sildenafil and 1 hour after. PAP and PAWP were measured.

**Results:** Table 1 shows hemodynamic measurements before and after sildenafil. Both PAP and PWAP were significantly reduced with sildenafil. Following the controlled study, our subject was prescribed 50 mg sildenafil to be taken one hour prior to competition. Since then she has successfully completed 10 triathlons within 16 months, 3 of which were ultraman competitions. She has been free of IPE symptoms in all competitions.

Table 1. Mean hemodynamics before and after sildenafil at rest and during immersed exercise in 20°C water

	Condition	MPAP (mmHg)	MPAWP (mmHg)	Heart Rate (beats/min)	Arterial pressure (mmHg)	Central venous pressure (mmHg)	Systolic blood pressure (mmHg)	Diastolic blood pressure (mmHg)	Cardiac output (L/min)
Dry, supine, rest	Pre-sildenafil	19.0	15.5	74	102.1	9.9	148	80	6.6
Immersed exercise	Pre-sildenafil	35.3	25.3	129	121.5	13.1	189	88	13.6
Dry, supine, rest	Post-sildenafil	18.8	15.2	64	95.4	9.9	134	74	7.5
Immersed exercise	Post-sildenafil	28.8	19.7	135	114.3	7.6	172	85	15.0

**Summary/Conclusions:** Sildenafil attenuates the immersed exercise pulmonary vascular responses that may cause IPE by inducing venodilation, presumably by reducing intrapulmonary blood volume and hence PAP and PAWP. These observations suggest that sildenafil may prevent IPE in susceptible individuals.

#### References:

- Adir Y, Shupak A, Gil A, Peled N, Keynan Y, Domachevsky L, et al. Swimming-induced pulmonary edema: clinical presentation and serial lung function. Chest 2004;126:394-9.
- Miller CC, 3rd, Calder-Becker K, Modave F. Swimming-induced pulmonary edema in triathletes. Am J Emerg Med 2010;28:941-6.
- Wilmshurst PT, Nuri M, Crowther A, Webb-Peploe MM. Cold-induced pulmonary oedema in scuba divers and swimmers and subsequent development of hypertension. Lancet 1989;1:62-5.

### Background

- Swimming-induced pulmonary edema (SIPE) occurs in susceptible individuals, who present with dyspnea, hemoptysis and cough during swimming or scuba diving, often in cold water.
- SIPE is consistent with hemodynamic pulmonary edema and may be the result of pulmonary capillary stress failure caused by high pulmonary artery and capillary pressures.
- The redistribution of blood from the periphery to the core during immersion results in an increased blood volume in the thorax. Augmentation of the normal increase in pulmonary artery and wedge pressures (PAP, PAWP) that occur during exercise may induce SIPE.
- It has been demonstrated that SIPE-susceptible individuals have significantly higher pulmonary artery pressure (PAP) and pulmonary artery wedge pressure (PAWP) than controls during immersed exercise in cold water.
- We have shown that these changes are attenuated by 50 mg of oral sildenafil prior to immersed exercise resulted in reduced PAP and PWAP.
- Sildenafil may be useful in protecting against SIPE by inducing systemic venodilation, thus providing a reservoir that could reduce the immersion-related peripheral-to-central redistribution of blood.

### Methods

An ultra-triathlete with a history of at least 5 episodes of SIPE was recruited. Medical history and clinic notes were obtained and evaluated to evaluate eligibility. IRB approval and informed consent were obtained. The subject was instrumented with PA and radial artery catheters. Submerged exercise in 20°C water was performed for 6 minutes prior to and 1 hour after administration of 50 mg oral sildenafil. The following measurements were taken during supine, dry rest and during submersed exercise: MPAP, PAWP, heart rate (HR), arterial pressure (AP), central venous pressure (CVP), blood pressure (BP), and Fick cardiac output (CO).

### Results

Table 1. Subject characteristics

Age	Gender	Height	Weight	BMI	Significant medical hx
46	F	1.44 m	58.9 kg	28.4 kg/m <sup>2</sup>	controlled HTN, 16 mg candesartan

Table 2. Mean hemodynamics before and after oral sildenafil (S) in 20°C water

	Pre-S Dry supine rest	Post-S Dry supine rest	Pre-S Immersed exercise	Post-S Immersed exercise
HR (bpm)	74	64	129	135
BP (mean) (mmHg)	148/80 (102)	134/74 (95)	189/88 (122)	172/85 (114)
CO (L/min)	6.6	7.5	13.6	15.0
CVP (mmHg)	9.9	9.9	13.1	7.6
Mean PAP (mmHg)	19.0	18.8	35.3	28.8
PAWP (mmHg)	15.5	15.2	25.3	19.7

- Sildenafil had minimal effect on resting hemodynamics. However, during immersed exercise, MPAP and MWAP were significantly reduced.
- After the conclusion of the study, our subject was prescribed 50 mg sildenafil by her local physician, to be taken 1 hour prior to triathlon events and swim training. Since then, she has participated in over 10 races, varying in difficulty from sprint triathlons to ultramans (swim length 0.5km-10 km, swim time 00:09:35 - 04:36:39), during which she has remained free of SIPE symptoms.

Figure 1. Subject submerged approximately 50 cm below the water and is situated for exercise. Subject is breathing from full face mask delivering isobaric air



### Conclusions

- Sildenafil attenuated the increase in pulmonary vascular pressures during immersed exercises that may cause IPE, presumably due to venodilation. This would reduce volume and pressure in the thoracic vasculature as a result of expansion of venous capacitance to accommodate blood from in veins that constrict in response to cold immersion.
- The apparent prevention of SIPE manifestations by sildenafil leads us to conclude that in SIPE-susceptible individuals, this drug may be useful to prevent pulmonary edema during competitive swimming events.

### References

- Adir Y, et al. Swimming-induced pulmonary edema: clinical presentation and serial lung function. Chest 2004;126:394-9.
- Miller CC, 3rd, et al. Swimming-induced pulmonary edema in triathletes. Am J Emerg Med 2010;28:941-6.
- Wilmshurst PT, et al. Cold-induced pulmonary oedema in scuba divers and swimmers and subsequent development of hypertension. Lancet 1989;1:62-5.

### Acknowledgement

The investigators are grateful to the Divers Alert Network and Naval Sea Systems Command for funding this work

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