

Retinal Venous Pressure and High Altitude



Disclosure

No commercial or financial interest
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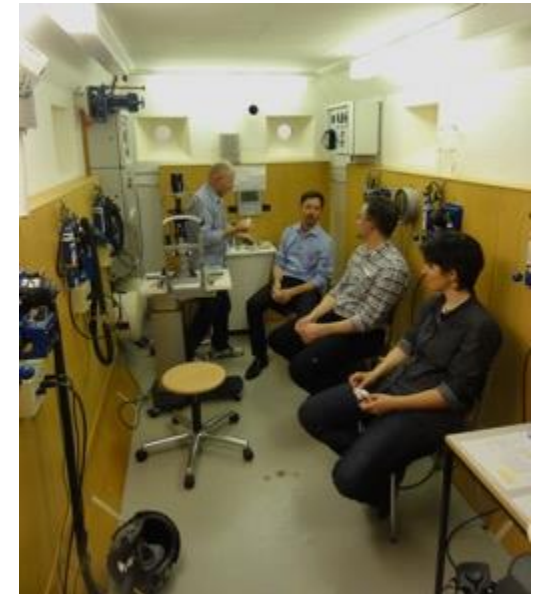
New England College of Optometry NECO



What does retinal venous pressure have in common with (dead) mountaineers on extreme high mountains ?



in a Low Oxygen Environment (Hypobaric chamber)



in a Low Oxygen Environment (Hypobaric chamber)

Goal: **To establish RVP in hypobaric (hypoxic) conditions of healthy subjects with and without Flammer Syndrome.**

Method: Experimental, prospective cohort study

Statistics: Descriptive, ANOVA, linear mixed model

Population: **23 healthy subjects**, 18-60yo

9x FS+ (39.1%) / 14x FS- (60.9%)

Altitudes: **300m (980ft)/ 2500m (8'200ft)/ 4200m (13'780ft)**

Gender: 13 women (56.5%) / 10 men (43.5 %)

Mean age: 32.5 yo women / 41.0 yo men

Intraocular Pressure, Oxygen Saturation, Pulse and Blood Pressure at all Altitudes

	N	Minimum	Maximum	Mean	Std. Deviation
SO2 300 (%)	23	95	99	98.22	.951
SO2 2500 (%)	23	90	97	94.74	1.936
SO2 4200 (%)	23	61	93	84.65	6.603
Puls 300 (beat/min)	23	52	102	76.78	12.767
Puls 2500 (beat/min)	23	53	102	77.74	12.516
Puls 4200 (beat/min)	23	52	110	79.30	12.633
BP Sys 300 (mm Hg)	23	93	165	130.09	20.095
BP Sys 2500 (mm Hg)	23	90	162	131.65	19.144
BP Sys 4200 (mm Hg)	23	92	171	132.57	21.179
BP Dia 300 (mm Hg)	23	50	109	82.48	14.343
BP Dia 2500 (mm Hg)	23	60	108	86.52	13.608
BP Dia 4200 (mm Hg)	23	60	119	85.78	15.929



Comparison of IOP in FS negative and FS positive Group

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for		Minimum	Maximum
						Mean			
						Lower Bound	Upper Bound		
IOP 300	1	14	16.9286	3.19770	.85462	15.0823	18.7749	12.00	23.00
	2	9	14.3333	1.80278	.60093	12.9476	15.7191	12.00	18.00
	Total	23	15.9130	2.98349	.62210	14.6229	17.2032	12.00	23.00
IOP 2500	1	14	15.6429	3.71291	.99232	13.4991	17.7866	10.00	22.00
	2	9	14.6667	2.44949	.81650	12.7838	16.5495	11.00	19.00
	Total	23	15.2609	3.25042	.67776	13.8553	16.6665	10.00	22.00
IOP 4200	1	14	14.2857	3.64646	.97456	12.1803	16.3911	9.00	21.00
	2	9	14.8889	2.20479	.73493	13.1941	16.5836	13.00	18.00
	Total	23	14.5217	3.11696	.64993	13.1739	15.8696	9.00	21.00

Group 1: Flammer Syndrome negative

(- 2.65mmHg)

Group 2: Flammer Syndrome positive

(+ 0.55mmHg)



Comparison of RVP in FS negative and FS positive Group

		N	Mean
RVP 300	1	14	26.2143
	2	9	24.8889
	Total	23	25.6957
RVP 2500	1	14	25.6429
	2	9	26.4444
	Total	23	25.9565
RVP 4200	1	14	27.0714
	2	9	27.5556
	Total	23	27.2609



p=0.744



p=0.839



p=0.909



Group 1: Flammer Syndrome negative (+0.9mmHg)

Group 2: Flammer Syndrome positive (+2.6mmHg)

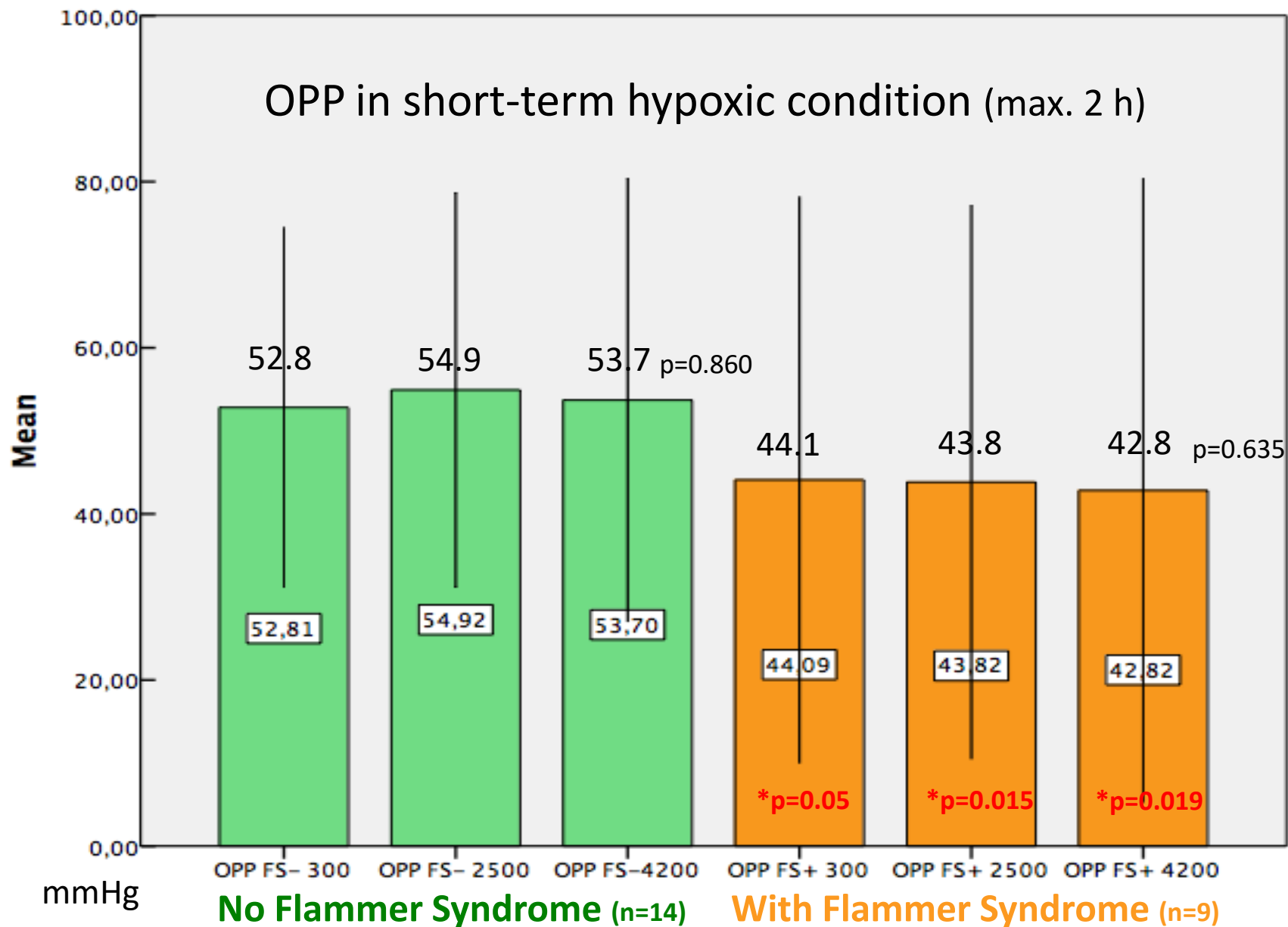
Descriptive Statistics for Mean Arterial Pressure at different Altitudes

	N	Minimum	Maximum	Mean	Std. Deviation
1 MAPFSneg300	14	82.00	128.00	103.5000	14.55361
MAPFSneg2500	14	86.00	126.00	108.1429	12.57505
MAPFSneg4200	14	78.00	130.00	108.2143	13.90174
2 MAPFSpos300	9	65.00	107.00	90.2222	* 15.22972
MAPFSpos2500	9	70.00	108.00	91.4444	** 13.38013
MAPFSpos4200	9	72.00	112.00	90.8889	** 16.41984
Valid N (listwise)	14/9				



* $p=0.260$

** $p=0.038$ / $p=0.038$



- Vital parameters such as oxygen saturation, pulse rate and blood pressure changed as expected. (Morganti et al. 1995)
- **RVP did not changed** significantly for both groups when confronted to hypoxia for less than 2h.
- **MAP and OPP** were significantly **lower for the FS+** group at **all altitudes**.
- Further studies are needed to investigate MAP in FS+
- Effect of **longer exposure time to hypoxia** on RVP in general.



Mt. Everest, 8'848m/29'029ft, May 2013

Aim 2: The influence of High Altitude to Retinal Venous and Ocular Perfusion Pressure

Goal: **To establish RVP and OPP in long-term hypobaric (hypoxic) conditions of healthy subjects.**

Method: Experimental, prospective cohort study

Statistics: Descriptive, ANOVA, linear mixed model

Population: **31/33 healthy subjects**, 18-60yo, **FS-**

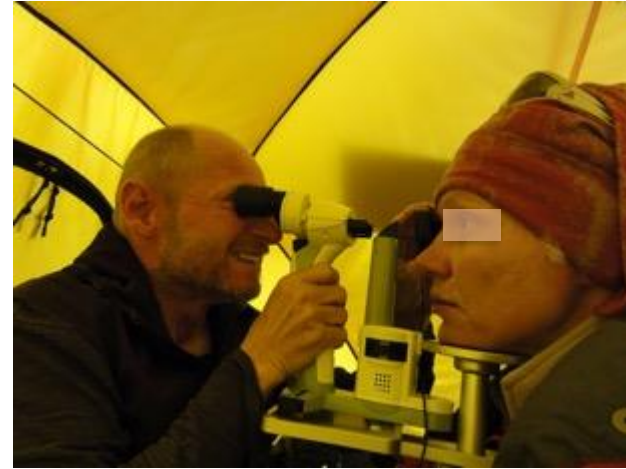
Altitudes: **300m (980ft)/ 4200m (13'780ft)/ 6000m (19'685ft)**

Mountains: Andes, Pamir, Karakorum, Himalaya

Gender: 6 women (18.2%) / 27 men (81.8 %)

Mean age: 43.8 yo women / 46.9 yo men

Aim 2: The influence of High Altitude to Retinal Venous and Ocular Perfusion Pressure



Pik Lenin, Camp 2, 6'000m/19'685ft

June 2012

Aim 2: The influence of High Altitude to Retinal Venous and Ocular Perfusion Pressure

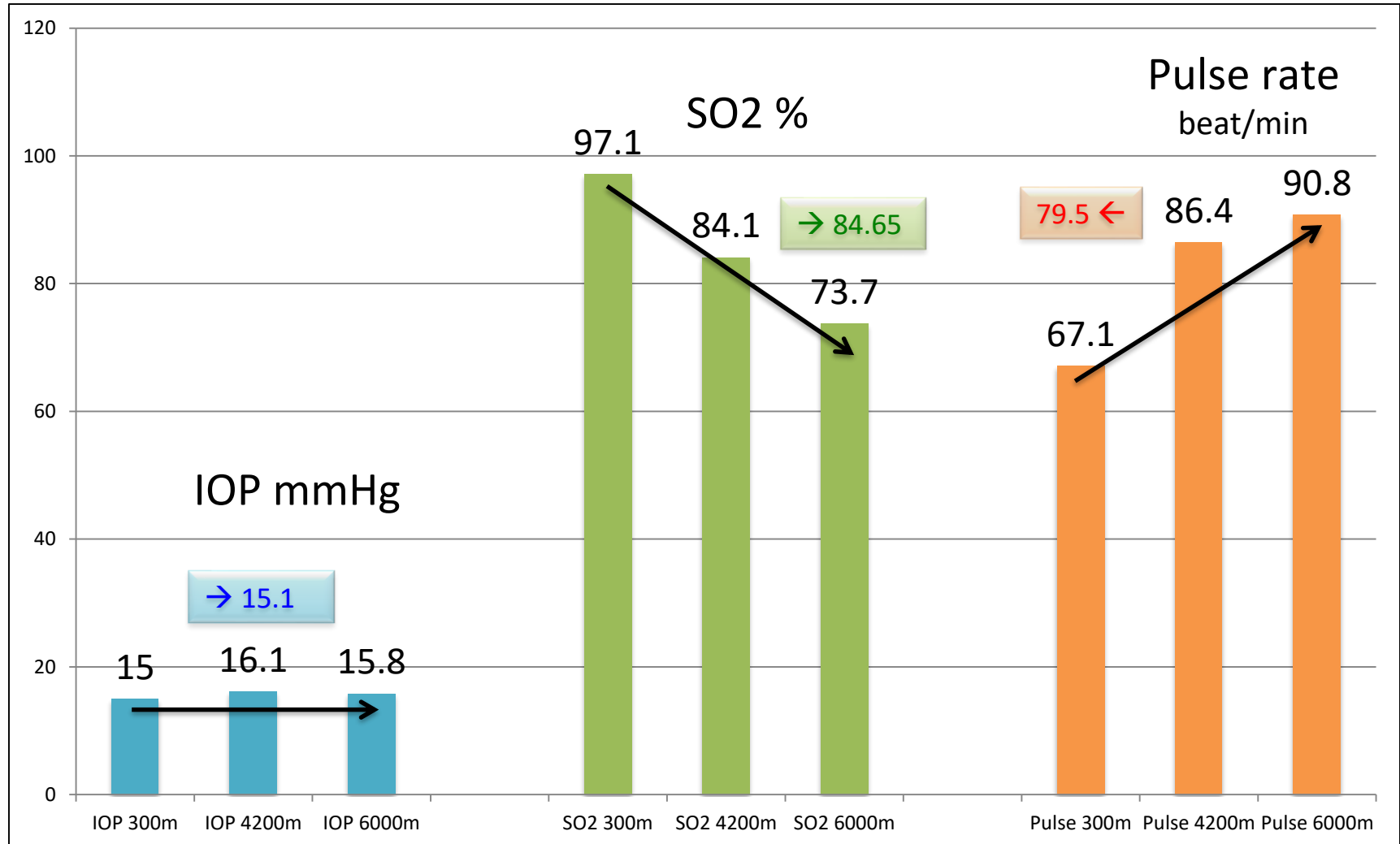


Aconcagua, Camp 3, 6'000m/19'685ft

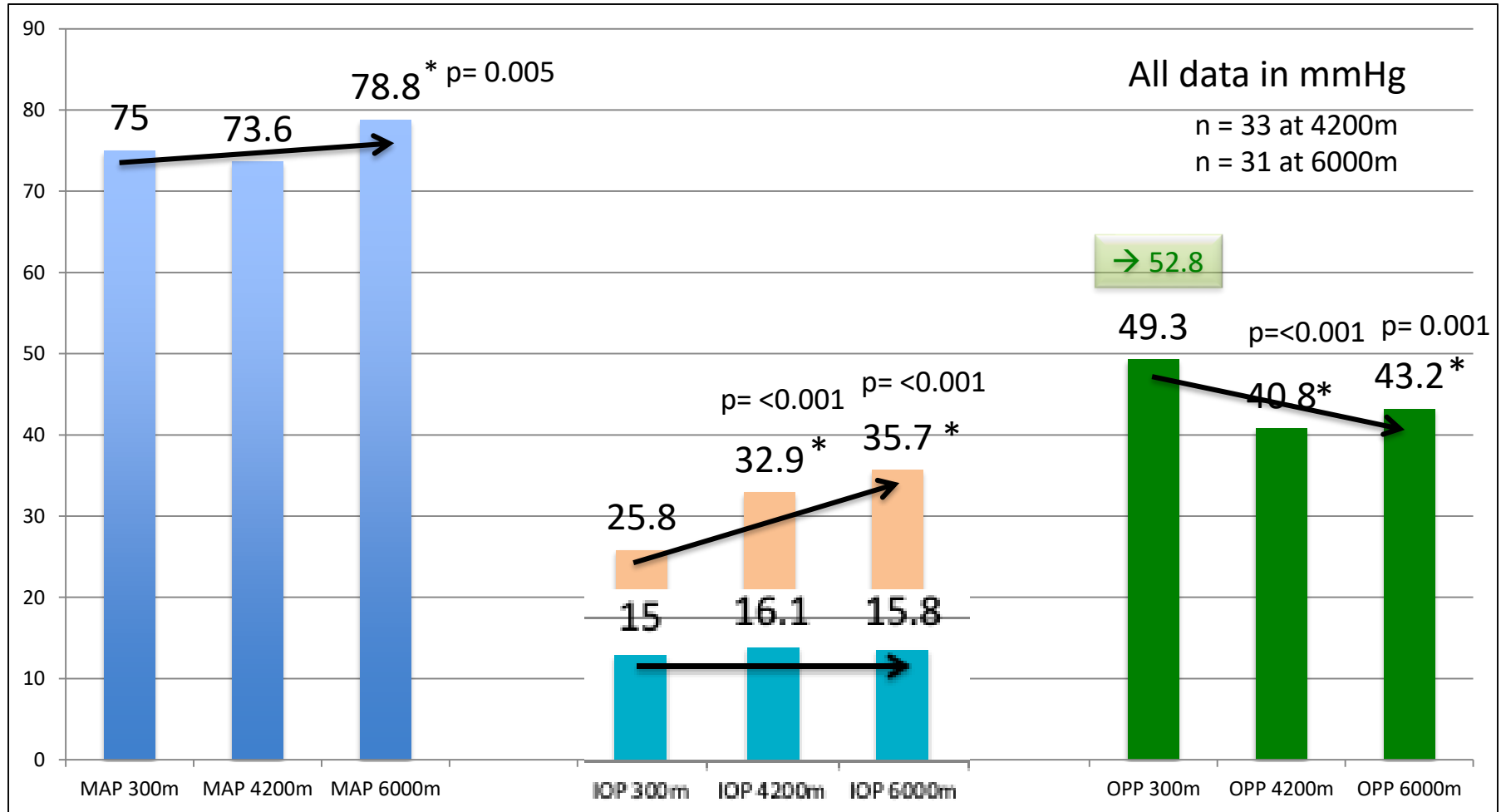
December 2011

IOP, SO2 and Pulse

at different altitudes (Hypoxia >24h) (n=33/31)

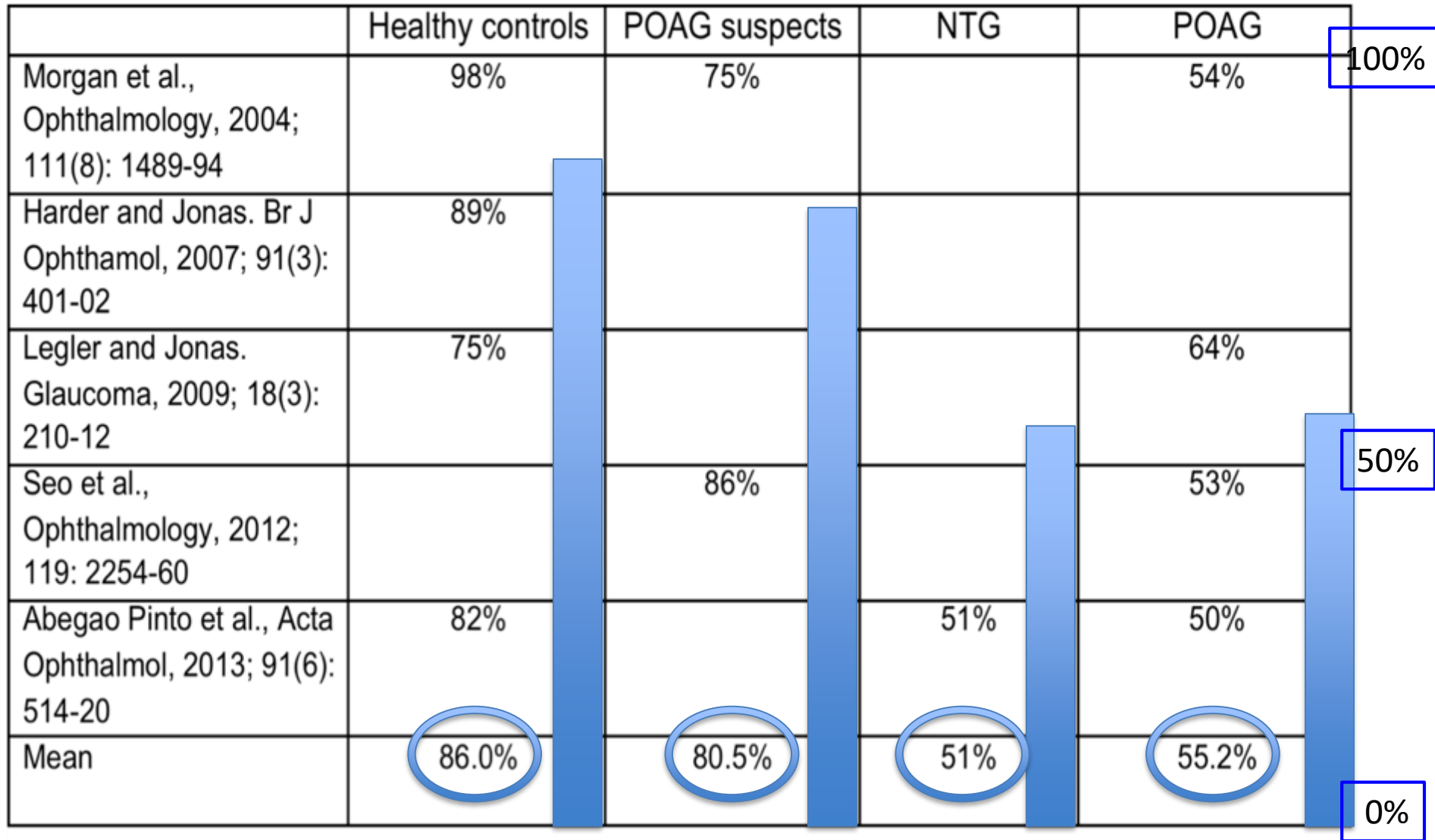


ocular MAP, RVP and OPP at different altitudes (Hypoxia >24h) (n= 33/31)



IOP not equal RVP !

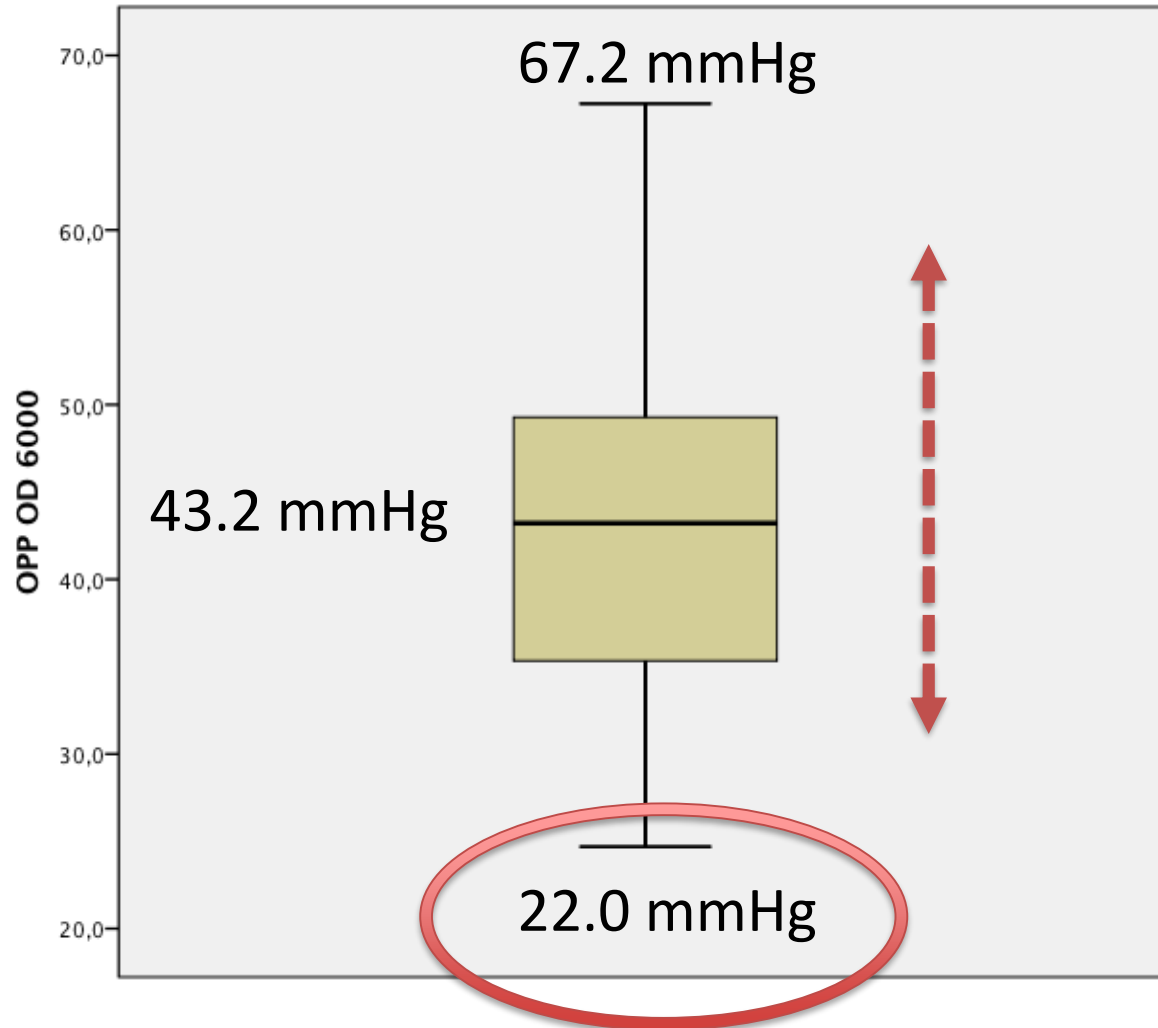
Prevalence of Spontaneous Retinal Venous Pulsation in five major studies



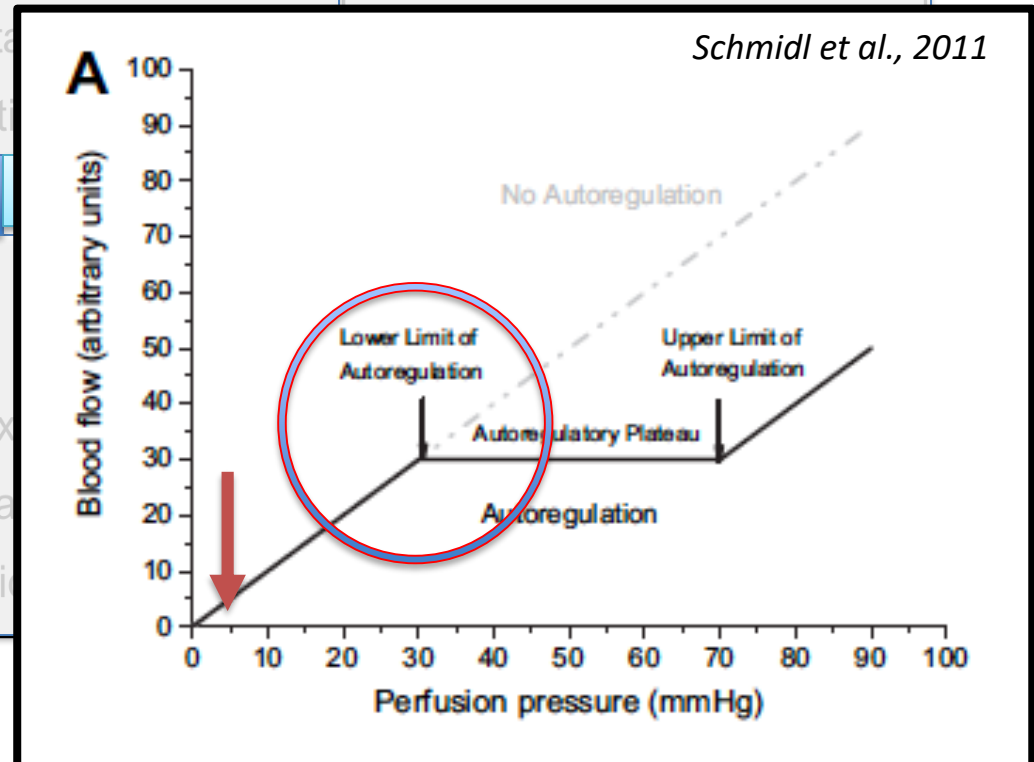
$$\text{Ocular Perfusion Pressure (OPP)} = 2/3 [\text{MAP}^*] - \text{RVP}$$

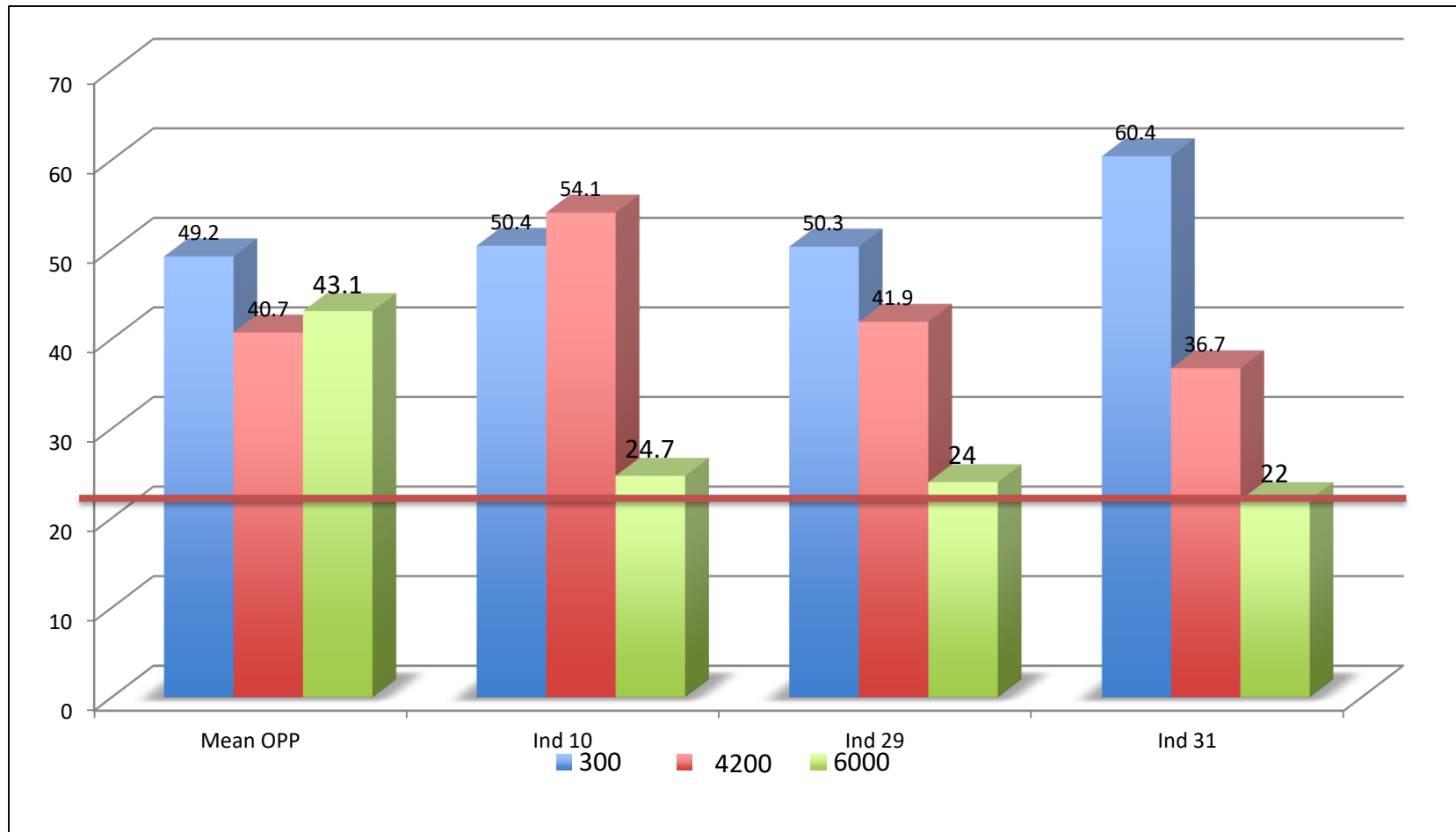
**MAP = Mean Arterial Pressure = BPdias + 1/3 (BP_{syst} – BPdias)*

Ocular Perfusion Pressure at 6000m (n=31)



Tissue	Function and characteristics	Involved cell or fiber layer
Retina	Autoregulation e.g. Flicker, IOP/ICP, Endothelin-1 Low flow rate Low perfusion rate Low venous oxygen saturation High vascular resistance High oxygen extraction	Inner limiting membrane Optic nerve fibers Ganglion layer Inner plexiform layer
Choroidea	No Autoregulation Very high flow rate High perfusion rate Very high venous oxygen saturation Low vascular resistance Low oxygen extraction	





Around Lower Limit of Blood Flow Autoregulation in Optic Nerve Head *

- ❖ Riva 1997 (22mmHg Humans), Riva 1996 (20mmHg Cat's)
- ❖ Schmidl 2011 (30mmHg Humans)



- Vital parameters such as oxygen saturation, pulse rate and blood pressure **changed as expected**. (Morganti et al. 1995)
- RVP increased significantly for **all altitudes** ($p < 0.001$)
- RVP reaction to hypoxia takes **>2h** but **<24h**.
- OPP decreased significantly for all altitudes despite the MAP increase. ($p < 0.001$)
- RVP and OPP varied among individuals.
- OPP levels could be as low as the **lower limit of autoregulation** at the optic nerve head. (Riva et al. 1996 and 1997, Schmidl 2011)

What does retinal venous pressure have in common with (dead) mountaineers on extreme high mountains ?



"partial or total circulatory collapse"

Answer:

The risk of becoming blind (or even to die) due to hypoxia

1. Retinal venous pressure (RVP) is an essential factor to establish the accurate retinal perfusion pressure.
2. RVP can be established precise, reproducible, quick and cost-effective by Ophthalmo-Dynamometry.
5. Ocular perfusion pressure (OPP) of subjects with FS+ is lower than in subjects without FS.
6. The physiological reaction of environmental hypoxia to RVP takes longer than 2 hours.
7. Constant environmental hypoxia increases RVP and lowers OPP despite an increase of mean arterial pressure MAP.



THANK YOU !

Broad Peak 8'051m/26'414ft, Pakistan, July 2018